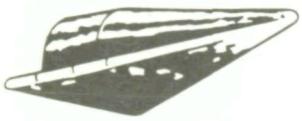

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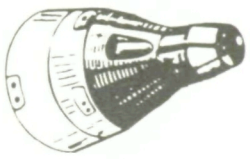

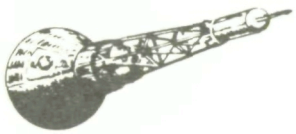

MDC E0377

Phase B System Study FINAL REPORT

DETAIL MASS PROPERTIES REPORT

Part II (B)

ORBITER DETAILS

HIGH VALUE

SPACE SHUTTLE

LOW COST

(NASA-CR-143901) SPACE SHUTTLE PHASE B SYSTEM STUDY. PART 2(B): ORBITER DETAILS. DETAIL MASS PROPERTIES REPORT Final Report (McDonnell-Douglas Corp.) 420 p

N75-76041

Unclas

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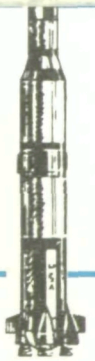

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MARTIN MARIETTA DENVER DIVISION

TRW SYSTEMS GROUP

PAN AM

REPORT MDC E0377
30 JUNE 1971

Space Shuttle System

PHASE B STUDY FINAL REPORT

Part II (B)
Orbiter Details

DETAIL MASS PROPERTIES REPORT

SUBMITTED UNDER

NASA CONTRACT NO. NAS 8-26016

DRD MA016M- DRL LINE ITEM 23

MCDONNELL DOUGLAS CORPORATION

MARTIN MARIETTA DENVER DIVISION

PAN AM

TRW SYSTEMS GROUP

VOLUME II

ORBITER DETAILED MASS PROPERTIES

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2.9 - APU POWER

General- Orbiter APU System Requirements and Criteria - The Auxiliary Power Unit must provide all hydraulic and AC electrical power requirements during Orbiter flight. These requirements are related to the mission operational phases:

Pre-launch:	APU start. Hydraulic and electrical systems checkout. Main engine propellant recirculation systems.
Ascent:	Main engine propellant recirculation systems. Main engine ignition and control. Thrust vector control. APU shutdown after orbital insertion.
On Orbit:	No requirements identified.
Reentry:	APU start. Hydraulic systems checkout. Vehicle control.
Cruise and Land:	Flight control, brakes, steering, etc. APU shutdown after taxi and park.

Fail operational, fail safe redundancy is achieved operationally by operating all four APU subsystems at the same time. In the event of a failure in any two of the four active subsystems, the remaining two systems insure safe return of the vehicle and crew. In the event of an APU malfunction shutdown, closing of the subsystem shutoff valves and the two sets of inlet isolation valves permits FO/FS isolation of the unit.

The APU system is also required to provide hydraulic and electrical power during ground maintenance operations. It must also incorporate, to the extent possible, provisions for the system to be thermally self-sufficient.

The required hydraulic and AC electrical power profiles are given in Sections 2.10 and 2.11. The maximum total energy output of each APU subsystem is 93 horsepower hours.

Each of the APU subsystems consists of combustor, turbine and gearbox assemblies, the necessary lines, isolation and shutoff valves, control valves and integrated control system, one AC generator and two hydraulic pumps, four heat exchangers, and those ancillary components required for lubrication and cooling. AC generator and hydraulic pump data are included in Sections 2.10 and 2.11 and are not repeated here.

APU system schematic is given on page 2.9-4 and basic system characteristics are summarized on pages 2.9-5 and -6. A detail system description is given in MDAC Memo No. SSPI-E450-587.

2.9 Prime Power - Cont.

Fuel Cell Subsystem - Four hydrogen-oxygen fuel cell modules are installed in the Orbiter. Each unit is capable of producing 7 kilowatts continuously and peaks of 14 kilowatts. The nominal output potential of the fuel cell modules is 120 vdc. Each fuel cell module supplies power to one of the four power distribution channels.

The fuel cell module is an electrical powerplant designed to convert the chemical combination of hydrogen and oxygen directly into electrical energy. The module consits of two sections: the stack of individual cells wherein the chemical reaction occurs, and the ancillary equipment (also indirectly provides product water for drinking).

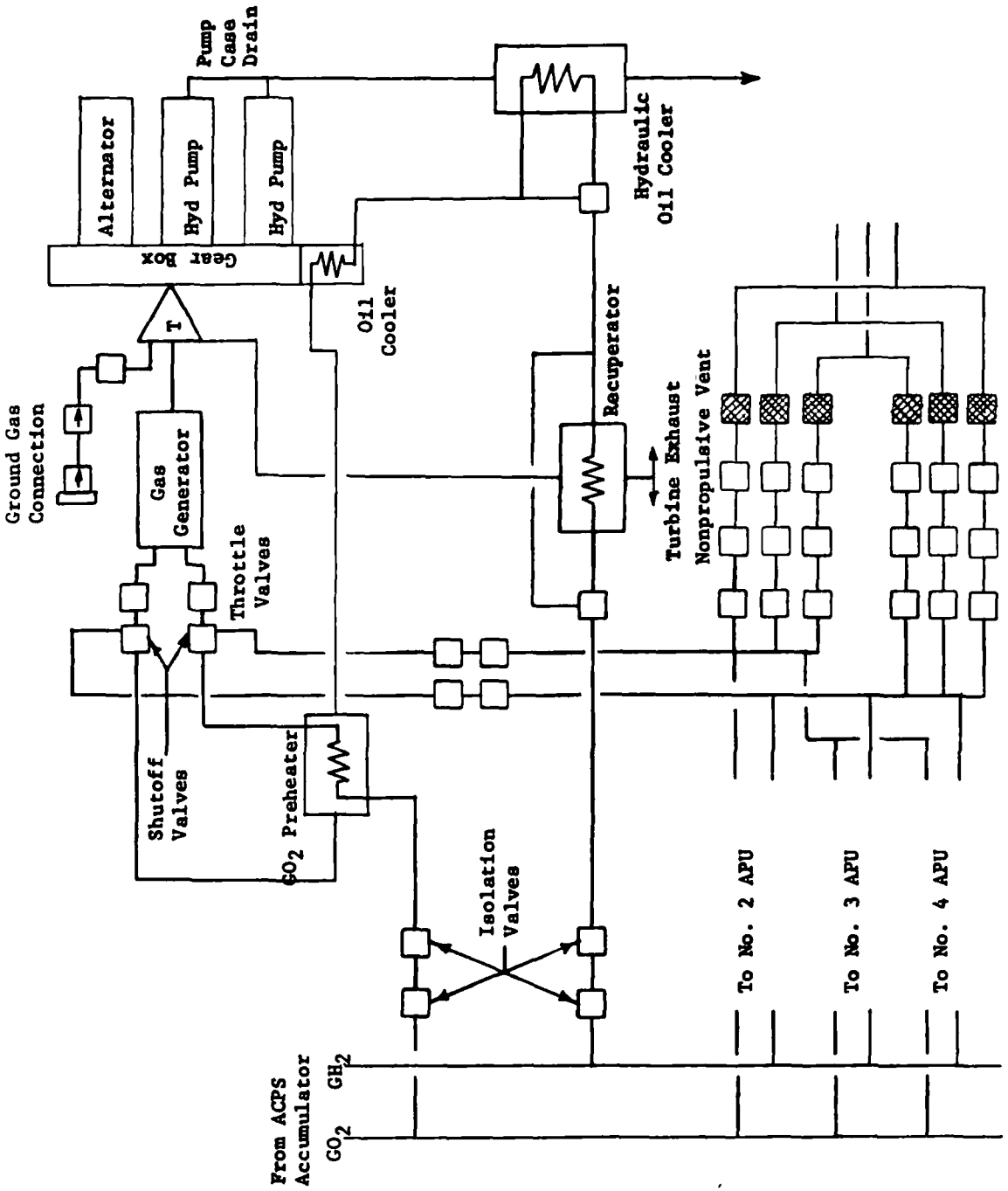
A pumped coolant system transports fuel cell waste heat to the vehicle coolant system. A temperature controlled bypass valve modulates the coolant flow returning to the stack, or passing through the vehicle/fuel cell module heat exchanger. Stack temperature is maintained at 190°F nominal.

Fuel cell reactants (hydrogen and oxygen) are supplied from a common storage system which supplies reactants for orbital maneuvering, attitude control, environmental control, APU (turbine) operation, and fuel cell operation. The reactants are stored as liquid (subcritical), pumped to high pressure (2000 psia) as a liquid gasified, and regulated to 700 $\pm$50 psia. The fuel cells are provided with this regulated pressure. While the reactants are in a gaseous state, minimum heat has been added so that the reactants are cool gases: 200°R hydrogen, and 300°R oxygen. (See Section 2.26 for 640 lb reactants weight.) Reactant flow, at an 8:1 mass ratio, is a demand function directly proportional to and inherently determined by current flow.

Fuel cell operational power profile is given on page 2.9-7. A detail system description is given in MDAC Memo No. SSPI-E450-586.

Methodology - Detail load profiles have been evaluated and peak power requirements as well as total energy requirements are established, therefore, weight data is based on the best available data sources in order to meet the established requirements. Trade studies have been performed to optimize these requirements and utilize the most favorable system concepts. Reference MDAC Memos No. SSPI-E450-586 and -595.

Based on data shown in Section 1.0, 296 pounds is allowed for contingency.



ORBITER APU SYSTEM SCHEMATIC

APU SYSTEM CHARACTERISTICS

No. APU's:	**4**
Hydraulic Horsepower:	**277 max.**
Gearbox Shaft Horsepower Output:	**320 max.**
Gearbox Idle Shaft Horsepower Output:	**32**
Duty Cycle:	**349 HP-HRS (total, 4 units)**
Operating Mode:	**4 Active Systems**
No. Hydraulic Pumps:	**2 per APU**
No. 15 KVA AC Generators:	**1 per APU (1)**
Speed Control:	**± 5% Turbine Speed Regulation Pressure Modulation**
Pump Case Drain Heat Load:	
@ Idle	**7.5 BTU/sec per pump**
@ Full Power	**15.5 BTU/sec per pump**
Turbine Inlet Temperature	**1960°R**
Turbine Inlet Pressure	**500 psia**
Turbine Shaft Speed	**70,000 rpm**

(1) 3 total, for system.

Propellants:
- Gaseous Hydrogen from ACPS accumulator supply
- Gaseous Oxygen from ACPS accumulator supply

Propellant Inlet Conditions at APU Interfaces:
- GH_2 @ 700 psia and 260°R
- GO_2 @ 700 psia and 360°R

Specific Propellant Consumption:

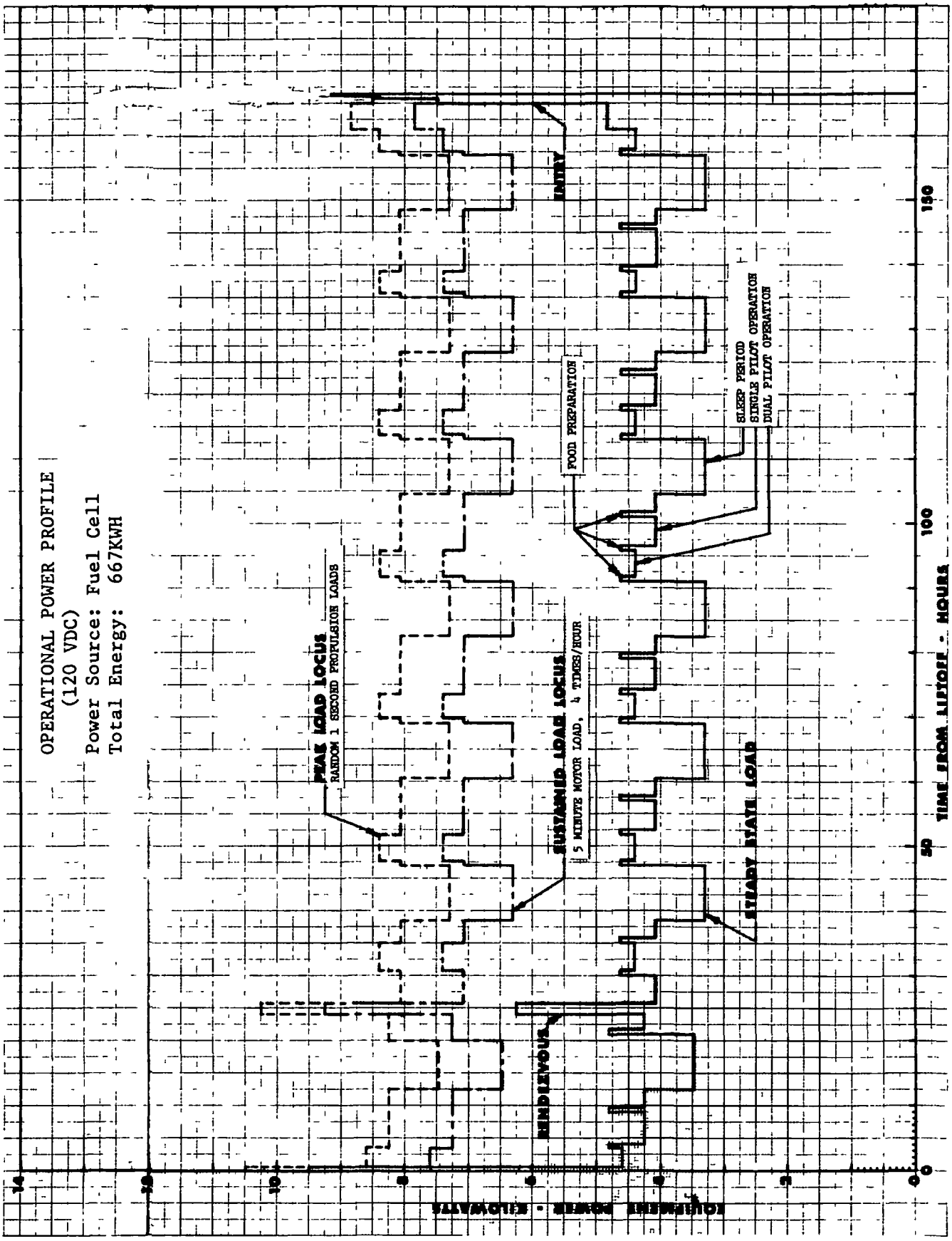
At maximum power at sea level:	2.06 lbs/HP-hr
At idle at sea level:	3.17 lbs/HP-hr
At nominal power at sea level:	2.27 lbs/HP-hr
At nominal power at very high altitude:	1.79 lbs/HP-hr

LOADED PROPELLANT WEIGHT COMPUTATION

FOR EACH LOAD INCREMENT:

1.	HYDRAULIC FLUID HORSEPOWER + HYDRAULIC PUMP LOSS + GEAR BOX LOSS	TURBINE SHAFT HP
2.	TURBINE SHAFT HP X DURATION	HP-HR INCREMENT
3.	MISSION ALTITUDE TIMELINE	TURBINE BACK PRESSURE
4.	TURBINE SHAFT HP AS % OF MAX. DESIGN TURBINE BACK PRESSURE	TURBINE SHAFT HP AND SPC, LB/HP-HR
5.	HP-HR INCREMENT X SPC	POUNDS OF PROPELLANT
6.	SUMMATION OF ALL INCREMENTS	MISSION PROPELLANT LOAD + GO-AROUND PROPELLANT + 5% CONTINGENCY TOTAL TURBINE CONSUMPTION
7.	TOTAL TURBINE CONSUMPTION @ 0.75 MIXTURE RATIO + CONDITIONING PENALTY (32%) @ 1.0 MIXTURE RATIO	
	TOTAL LOADED PROPELLANT WEIGHT	

NOTE: TOTAL APU PROPELLANT REQUIREMENT IS 953 LBS. AND IS CODED IN SECT'S. 2.26 & 2.25.


OPERATIONAL POWER PROFILE
(120 VDC)
Power Source: Fuel Cell
Total Energy: 667KWH
PEAK LOAD LOCUS
RANDOM 1 SECOND PROPULSION LOADS
SUSTAINED LOAD LOCUS
5 MINUTE MOTOR LOAD, 4 TIMES/HOUR
STEADY STATE LOAD
ENTRY
FOOD PREPARATION
SLEEP PERIOD
SINGLE PILOT OPERATION
DUAL PILOT OPERATION
RENDEZVOUS
TIME FROM LIFTOFF - HOURS
0
50
100
150
2
6
10
14
18
KILOWATTS - POWER DEMAND

GROUP WEIGHT STATEMENT

2.9 PRIME POWER — 2272

	POWER UNIT	MTG/ INSTAL.	PROPEL TANK/SYS	TEMP CONTROL	CONTROLS	TOTAL
BATTERIES	N/A	N/A	N/A	N/A	N/A	(N/A)
ENGINE/TURBINE	368	245	N/A	264	48	(925)
FUEL CELL	980	36	N/A	24	11	(1051)
CONTINGENCY						(296)

WEIGHT SUBSTATIATION

ITEM	REF NO. PG. 2.9-11	UNIT WT.	QTY	TOTAL WEIGHT
ENGINE/TURBINE				[925]
TURBINE POWER UNIT	1.	(92)	4	(368)
TURBINE (WITH CONTAINMENT)		44.0		
COMBUSTOR (WITH INSUL.)		4.0		
GEAR BOX WITH LUBE PUMP		44.0		
TEMP. CONTROL SYS.		(66.0)	4	(264)
LUBE OIL/COOLING		10.7		
RECUPERATOR		19.5		
H_2 PREHEATER		2.9		
O_2 PREHEATER		0.6		
HYDRAULIC OIL COOLER		5.5		
LUBE OIL COOLER		2.0		
DUCTING		24.8		
CONTROLS		(12.0)	4	(48)
VALVES		6.0		
CONTROLLER		6.0		
MTG/INSTALLATION				(245)
TURBINE/H.X MOUNTS	1.	30.0	4	120
APU VENT LINE (REF PG 2.9-10)		125.0	1	125

2.9 PRIME POWER

WEIGHT SUBSTANTIATION

ITEM	REF. NO. PG. 2.9-11	UNIT WT	QTY	TOTAL WEIGHT
FUEL CELL				[1051]
POWER UNIT 7/14 KW	2.	245	4	(980)
MOUNTING STR.	3.	.412(980)·65 =		(36)
TEMP. CONTROL				(24)
HEAT EXCHANGER	EST.	6	4	24
CONTROLS	EST.			(11)
CONTINGENCY				[296]
TOTAL PRIME POWER				2272

2.9 PRIME POWER

WEIGHT SUBSTANTIATION

APU VENT LINE

EST. 7" DIAM x .025 "WALL ~ CRS STEEL @ 1.9 LB/FT

EST. 600" LONG = 50 FT.

WT OF VENT LINE = 50 x 1.9 =	95.
VENT (NON PROPULSIVE) EST.	5.
MOUNTING ESTIMATED @ 25% =	25.
TOTAL VENT WT.	125 LB

2.9 PRIME POWER

REFERENCES & DATA SOURCES

1. ENGINE/TURBINE WEIGHTS ARE BASED DIRECTLY ON DATA CONTAINED IN PHASE I FINAL REPORT, PRELIMINARY DESIGN OF AN AUXILIARY PROPULSION UNIT (APU) FOR THE SPACE SHUTTLE, 70-7014 DECEMBER 15, 1970, CONTRACT NAS 3-14408, PREPARED FOR LEWIS RESEARCH CENTER, NASA, CLEVELAND, OHIO (GARRET) AIRESEARCH MANUFACTURING, LOS ANGELES, CALIF.
2. FUEL CELL WEIGHT DATA COMES DIRECTLY FROM PRATT & WHITNEY DESIGN DATA.
3. METHODOLOGY FOR MOUNTING STRUCTURE IS GIVEN IN SECTION 2.13.

2.10	Electrical	[1303]	
			Page No.
	Equipment		
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	Main Power Control Units	(216)	2.10-8
	AC Controllers	(69)	2.10-8
	Distribution & Control Circuitry	[435]	2.10-9
	Primary Feeders	(342)	2.10-10
	Secondary Feeders	(93)	2.10-9
	Utility Systems (Landing Lights)	[30]	2.10-8
	Supports/Installation	[24]	2.10-8
	Contingency	[213]	2.10-3

2.10 Electrical

General - Generator Subsystem - Alternating current (400 Hertz), for the main propulsion engines and the propellant recirculation pumps, is produced by three ac generators. Each generator is driven by one of three turbine power units (APU) that drive the hydraulic system pumps. The generators are mounted to the gearbox of the APU. Turbine speed control is utilized to maintain generator frequency. The generators are not paralleled. (See Section 2.9 for APU System.)

Each generator is a 120/208-volt, 3-phase, 400-Hertz, 4-pole, 12000-rpm, brushless, oil-cooled machine rated at 15 kilovolt-amperes to supply the power shown on page 2.10-4 at a .75 power factor. This type of machine is normally used on aircraft as part of an integrated drive generator system. However, for the Space Shuttle Orbiter vehicle, the constant speed drive is eliminated, and the generator interfaces directly with the APU gearbox. Generator frequency is dependent upon turbine speed control which is $\pm$5%.

Distribution Subsystem - Four isolated distribution channels are provided for compatibility with the "fail operational, fail operational, fail safe" criteria. Load LRUs which are redundant to each other are connected to separate distribution channels. These distribution channels are physically separated from each other to prevent a catastrophic fault in one from propagating to, or degrading, the remaining channels.

The Main Power Control Unit (MPCU) provides the primary power control for each distribution channel. The major components contained in the MPCU are a ground power contactor, a bus tie contractor, six feeder power controllers and a dc/dc converter that provides control power for the MPCU.

The Power Distribution Units (PDU) provide power control and power circuit protection for individual vehicle loads. Each PDU is tailored for the particular vehicle load center in which it is installed.

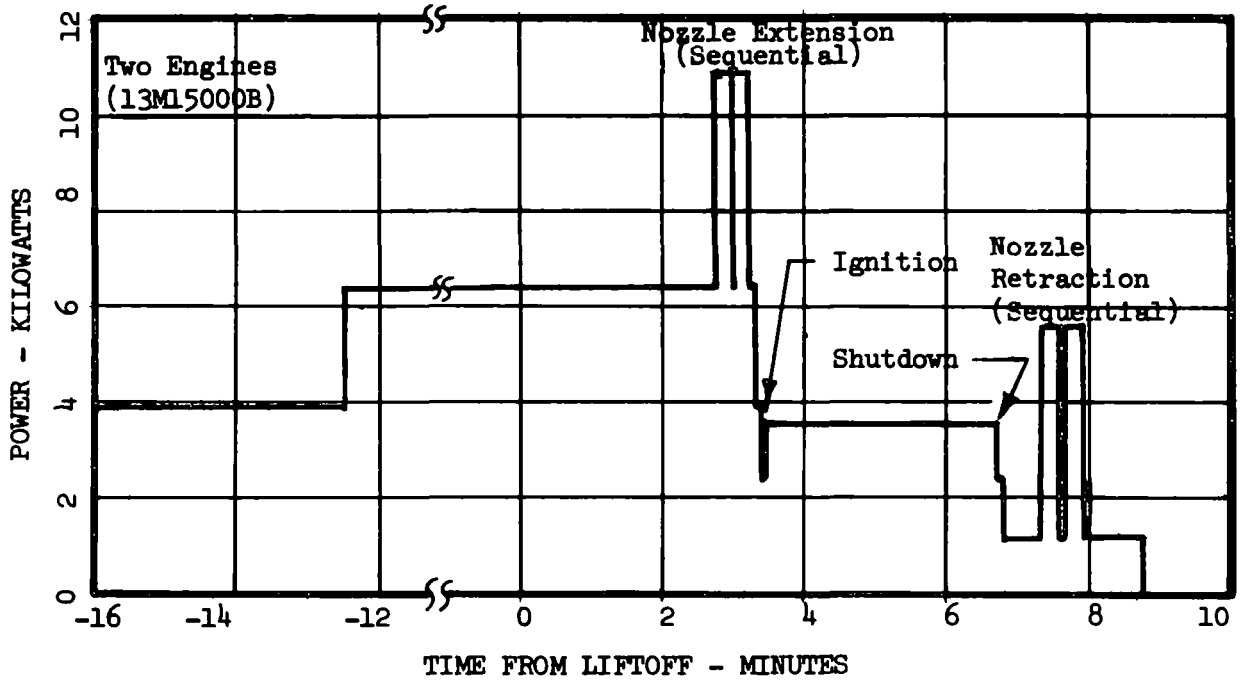
The power distribution units are composed of remote power controllers (RPC) and their associated wiring. The RPCs are solid state devices with certain exceptions where hybrid devices are used to control heavy loads, such as the electrically driven thermal equilization pumps for the hydraulic subsystem.

The generator control units contain the voltage regulator and protective circuits for operating the ac generator. Solid state components are used to meet the environmental requirements. The control unit is powered from the permanent-magnet generator on the main generator rotor.

Power distribution subsystem schematic and general arrangement are shown on pages 2.10-5 & -6. A detail system description is given in MDAC Memo No. SSPI-E450-586.

Methodology - An item-by-item weight analysis is shown on the following pages. Component weights are based on existing hardware data and/or vendor estimates which have been compared with similar hardware data. A detail calculation of wiring requirements is shown on pages 2.10-9 and -10. Wire routing lengths are based on estimates of "real" routing paths and which are tabulated on page 2.10-5. Wire size is estimated based on a cursory review of element load requirements. An allowance of 50% is made for connectors, supports and misc. installation provisions. This allowance is based on past MDAC experience and is verified by actual hardware data. Additional secondary circuitry allocations are made for individual components and are reported with the subsystem receiving power (example see section 2.13 Avionics.) Based on data shown in Section 1.0, 213 pounds is allowed for contingency.

AC POWER PROFILE
(120/208-V, 3-ϕ, 400-Hz)



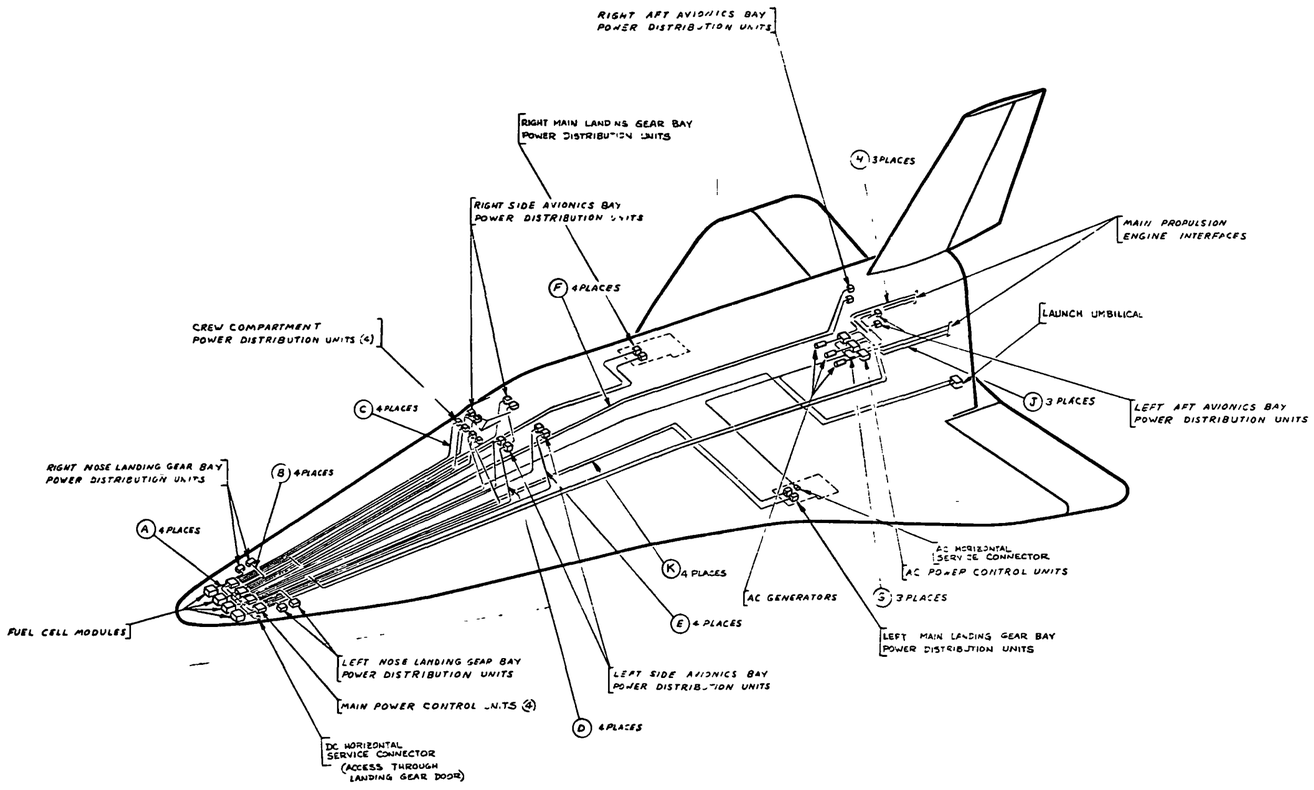


TABLE 1

ESTIMATED WIRE LENGTHS OF PRIMARY POWER FEEDERS

ROUTING PATH	LENGTH (FEET)
A	10
B	12
C	69
D	65
E	75
F	175
G	15
H	48
J	48
K	150

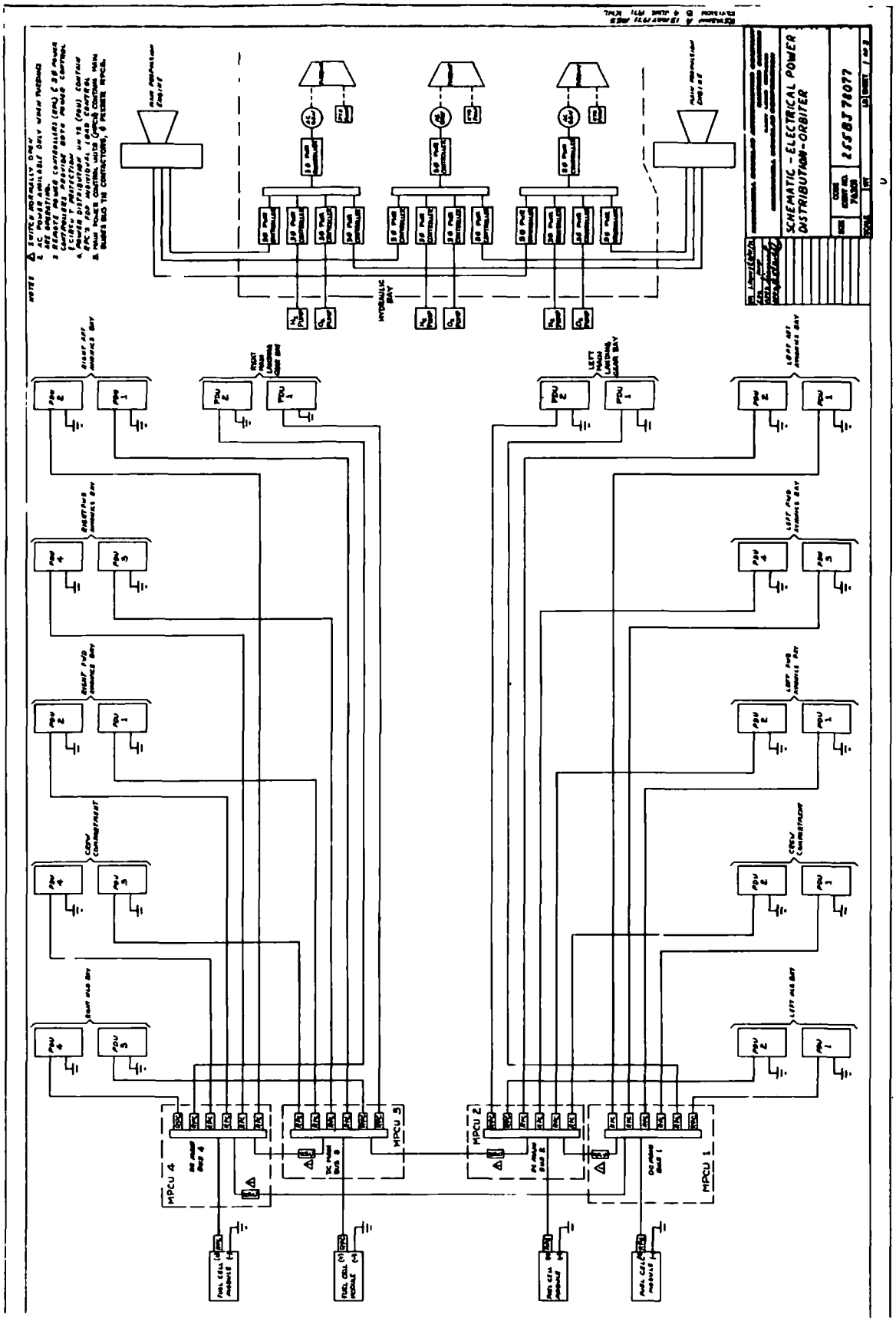
NOTES 1. SYMBOL (X) DENOTES WIRE ROUTING PATH. SEE TABULATION FOR ESTIMATED LENGTH.
2. SEE DWG NO 2558J78077 FOR CIRCUITRY

DR W.H. LAUNER (3 PART)
CHK R.E.S.
STR
GR (3 PART)
(2 PART)

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION
SAINT LOUIS MISSOURI
MCDONNELL DOUGLAS CORPORATION

INSTALLATION - ELECTRICAL POWER SUBSYSTEM - ORBITER

SIZE J | CODE IDENT NO 76301 | 2558J78079
SCALE | WT | LB SHEET


SCHEMATIC - ELECTRICAL POWER DISTRIBUTION-ORBITER
HYDRAULIC BAY
MPCU 4
MPCU 3
MPCU 2
MPCU 1

GROUP WEIGHT STATEMENT

2.10 ELECTRICAL	SUPPLY	CONVERSION	CONTROL UNITS		1303
EQUIPMENT	90	N/A	511	601	
DISTRIBUTION AND CONTROL CIRCUITRY				435	
UTILITY SYSTEMS (LANDING LIGHTS)				30	
SUPPORTS/INSTALLATION				24	
CONTINGENCY				213	

WEIGHT SUBSTANTIATION

ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT	PAGE NO.
			(601)	
EQUIPMENT				
* SUPPLY (GENERATORS)	30.0	3	90	
CONTROL UNITS			511	2.10-8
DISTRIBUTION & CONTROL CIRCUITRY			(435)	2.10-9
UTILITY SYSTEMS			(30)	2.10-8
SUPPORTS/INSTL.			(24)	2.10-8
CONTINGENCY			(213)	2.10-3
TOTAL ELECTRICAL			1303	

* SEE PAGE 2.10-11 REFERENCE NO. 1

2.10 ELECTRICAL EQUIPMENT

ITEM	REF. NO, Pg 2.10-11	UNIT WT	QTY	TOTAL WEIGHT
POWER DISTRIBUTION UNITS (PDU)				(225.94)
REMOTE POWER CONTROLLERS	2.	.1875	565	105.94
PDU BOXES		5.0	24	120.00
MAIN POWER CONTROL UNITS				(216.00)
[2] POWER CONTACTOR	3.	6.0	32	192.00
DC-DC CONVERTER		1.0	4	4.00
MAIN PWR CONTROL BOXES		5.0	4	20.00
AC CONTROLLERS				(69.00)
[1] 3 Φ POWER CONTACTORS	4.	3.0	18	54.00
AC CONTROL BOXES		5.0	3	15.00
		TOTAL CONTROL UNITS		510.94
LANDING LIGHTS		8.0	3	24.00
CIRCUITRY	5.	$.039(24)^{1.298}$ =		2.41
MOUNTING STRUCT.	5.	$.412(24)^{.65}$ =		3.25
		TOTAL UTILITY SYSTEMS		29.66
EQUIPMENT SUPPORTS & INSTL.	5.	$.412(510.94)^{.65}$		23.73

NOTES:

[1] 6 PWR CONTACTORS/BOX × 3 BOXES REQ'D = 18 TOT. CONTACTORS

[2] 8 PWR CONTACTORS/BOX × 4 BOXES REQ'D = 32 TOT. CONTACTORS

2.10 ELECTRICAL

POWER DISTRIBUTION CIRCUITRY – CON'T

WIRE WEIGHT PER MIL-W-81381/3

SECONDARY FEEDERS (EST #20 WIRE @ .0055 #/FT & 20 FT/UNIT = .11 #/UNIT)

ITEM	NO. OF UNITS/PDU PDU #1	PDU #2	PDU #3	PDU #4	TOTAL NO. OF UNITS
N.L.G. BAY	6	7	7	5	25
CREW STA.	18	16	15	13	62
L.H. FWD BAY	17	17	39	39	112
R.H. FWD BAY	18	12	38	38	106
L.H MLG BAY	8	9	–	–	17
R.H MLG BAY	7	9	–	–	16
L.H AFT BAY	52	61	–	–	113
R.H AFT BAY	57	57	–	–	114
			TOTAL		565

TOTAL SECONDARY FEEDERS WIRE WT
= 565 x .11 = 62.15

ADD 50% FOR CONNECTORS, SUPTS & INSTL. 31.08

* TOTAL SECONDARY FEEDERS 93.23 LB

TOTAL PRIMARY FEEDERS (PG 2.10-10) 342.00

TOTAL POWER DISTRIBUTION CIRCUITRY 435.23

* REFERENCE SECT. 2.13 FOR ADDITIONAL CIRCUITRY ALLOCATIONS.

2.10 ELECTRICAL

POWER DISTRIBUTION CIRCUITRY

WIRE WEIGHT PER MIL-W-81381/3

WIRE ROUTING LENGTHS FROM PAGE 2.10-5

ITEM	ESTIMATED WIRE SIZE	UNIT WT LB/FT	ROUTE LENGTH FT.	*	QTY	TOTAL WIRE WT LB.
PRIMARY FEEDERS						
MAIN PWR CNTL STA.	#4	.1501	10	A	4	6.00
L.H. N.L.G. BAY	#12	.0231	12	B	2	.55
R.H. N.L.G BAY	#12	.0231	12	B	2	.55
CREW COMPART.	#12	.0231	69	C	4	6.38
FRONT L.H FWD AV BAY	#12	.0231	65	D	2	3.00
FRONT R.H. FWD AV. BAY	#12	.0231	65	D	2	3.00
BACK L.H FWD AV. BAY	#12	0231	75	E	2	3.47
BACK R.H FWD AV. BAY	#12	.0231	75	E	2	3.47
L.H M.L.G BAY	#20	.0055	150	K	2	1.65
R.H M.L.G BAY	#20	.0055	150	K	2	1.65
L.H AFT AV. BAY	#4	.1501	175	F	2	52.54
R.H AFT AV BAY	#4	.1501	175	F	2	52.54
AC PWR CNTL	#4	.1501	15	G	3	6.75
MAIN ENG INTFC.	#8	.064	48	H & J	6	18.43
LAUNCH UMBIL.-DC	#4	.1501	175	EST	1	26.27
LAUNCH UMBIL - AC	#4	.1501	60	EST.	1	9.01
GSE CONNECT - AC	#4	.1501	80	EST.	1	12.01

* LTR DESIGNATION FROM TABLE 1 ON PAGE 2.10-5

SUBTOTAL WIRE WT 207.27

ADD' 50% FOR CONNECTORS, SUPTS & INSTL. 103.64

TOTAL WEIGHT PRIMARY FEEDERS 310.91

+ 10% ALLOWANCE FOR RETURNS TO STRUCTURAL GROUND 31.09

TOTAL PRIMARY FEEDERS 342.00

2.10 ELECTRICAL

LIST OF REFERENCES & DATA SOURCES

1. GENERATOR UNIT WT = 30LB, BASED ON BENDIX TYPE 28B231-2, AC BRUSHLESS GENERATOR, RATING: 7600/8400 RPM, 120/208 VOLTS, 3 PHASE, 380/420 CPS, 15 KVA.
2. REMOTE POWER CONTROLLERS, UNIT WT = 3 OZ. BASED ON LEACH RELAY RESPONSE TO MDAC RFTI # 001.
3. POWER CONTACTOR UNIT WT = 6 LB, BASED ON CUTLER-HAMMER RESPONSE TO MDAC RFTI # 006.
4. AC-3Ø POWER CONTACTORS UNIT WT = 3LB, ESTIMATED FROM PART NO. MS27714.
5. SEE SECT. 2.13 FOR CIRCUITRY AND MOUNTING STRUCTURE METHODOLOGY.

2.11 Hydraulic 2760

		Page No.
Power Supply	[552]	2.11-10
Main Pump	(320)	2.11-10
Reservoir	(232)	2.11-13
Distribution Control Ctr.	[704]	2.11-10
Pump Manifold	(189)	2.11-10
Valves and Controls	(217)	2.11-10
Circuitry	(96)	2.11-10
Plumbing	(208)	2.11-18
Temperature Control System	[284]	2.11-10
Cryo H_2 H.X.	(240)	2.11-19
Valves and Controls	(12)	2.11-19
Plumbing & Misc.	(32)	2.11-19
Auxiliary Systems	[88]	2.11-10
Secondary Elec. Pump	(80)	
Circuitry	(8)	
Supports/Installation	[420]	2.11-10
Local Mounting	(82)	2.11-27
Equip. Bay Structure	(338)	2.11-27
Contingency	[712]	2.11-3

2.11 Hydraulic Conversion and Distribution

General - The hydraulic system selected for the orbiter consists of four completely independent systems operating at 3000 psig nominal. Flow to each system is provided by two variable displacement, pressure compensated pumps which are driven by $H_2 - O_2$ turbine power units (TPU). Each system has a hydraulic output capacity of 277 horsepower. The selected system incorporates the latest state-of-the-art devices for failure detection and correction, and automated checkout. A significant improvement in this system is accomplished by the elimination of the need for accumulators. A functional diagram is shown on page 2.11-4. Detailed substantiation data is provided in MDAC Memo No. SSPI-E450-587.

Requirements - The hydraulic system shall provide energy for the following functions:

- Actuation of primary aerodynamic flight controls (elevons and rudders) during ascent, reentry, cruiseback, approach and landing
- Actuation of secondary flight controls (ABES deployment and speed brakes) during cruiseback, approach and landing
- Actuation of main engine thrust vector control (TVC) during ascent and retention of engines in the desired position during orbit, reentry, cruiseback, approach and landing
- Actuation of main engine fuel and oxidizer flow control valves and nozzle actuation for one of the three engine designs being evaluated
- Actuation of cargo doors and ECLS radiator during orbit and for ground handling and ACPS doors during orbit
- Actuation of utility functions (landing gear, brakes and steering during approach and landing

The design parameters associated with these functions are shown on page 2.11-5.

The system is required to provide sufficient redundancy to permit mission success after the failure of one hydraulic system and safe return after the failure of two hydraulic systems. The safe return condition is the same as full operational; therefore, the system is designed to "fail operative - fail operative".

The hydraulic system load profile from which the 277 max H.P. rating is derived is shown on page 2.11-6. The basic hydraulic power generation circuit is shown on page 2.11-8 and the complete hydraulic system schematic is shown on page 2.11-9.

2.11 Hydraulic Conversion and Distribution (Cont.)

Methodology - An item-by-item weight analysis using the hydraulic system schematic and equipment locations outlined on page 2.11-7 has been performed and appears on the following pages. Major component weights are based on actual hardware data for components with specifications similar to those required by the system.

Detail plumbing requirements are established using the analytical method shown on pages 2.11-18 and -20. Also, a detail analysis of general reservoir sizing requirements is given on page 2.11-13.

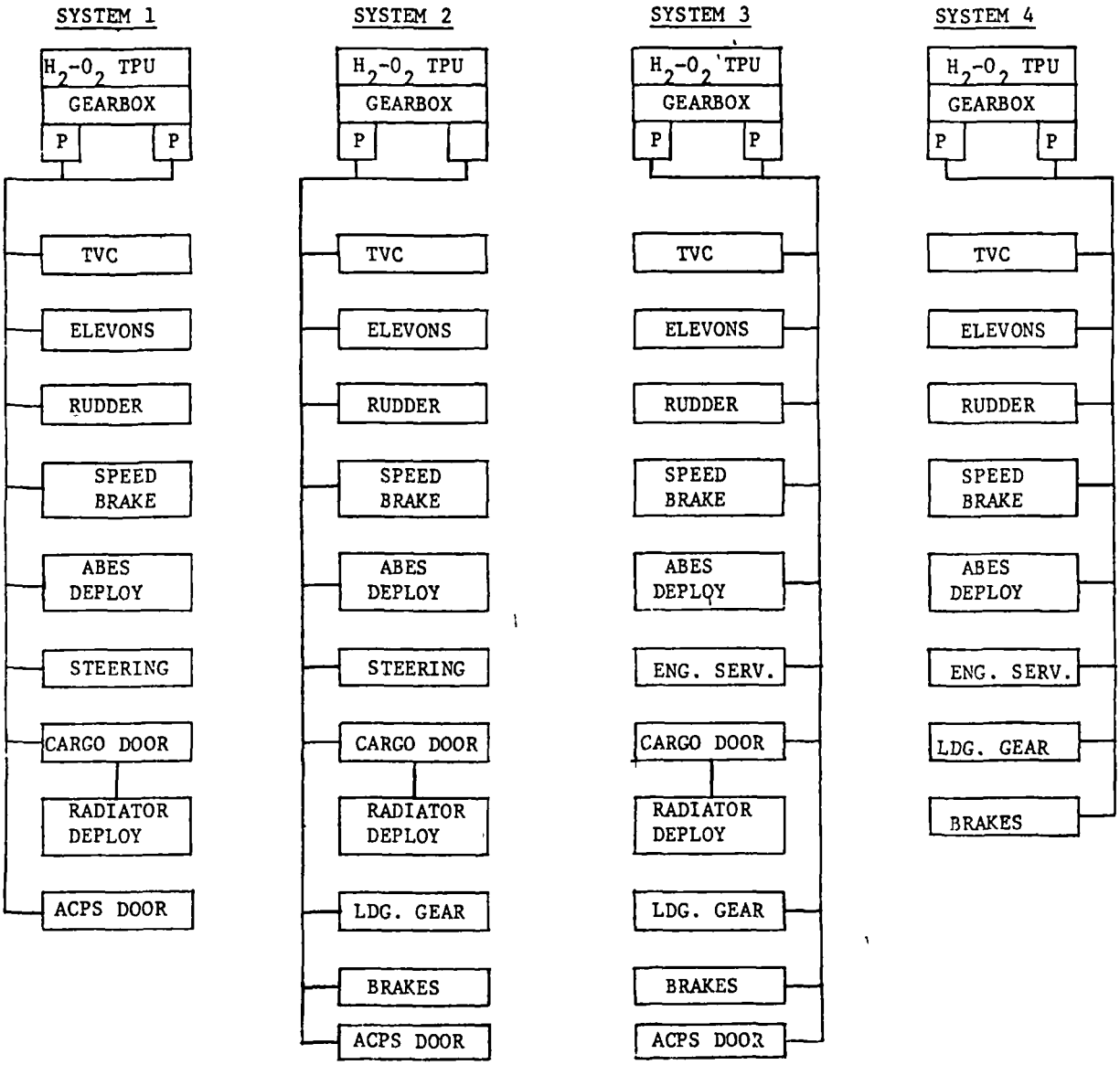
General methods used for estimating mounting structure and circuitry are the same as those given in Section 2.13.

Hydraulic fluid weight is calculated in detail in this section but is not included in the dry weight summary given on page 2.11-1. It is coded and listed in detail in Section 2.23, Residual Fluids.

Based on data shown in Section 1.0, 712 pounds is allowed for contingency.

WEIGHT SUBSTANTIATION

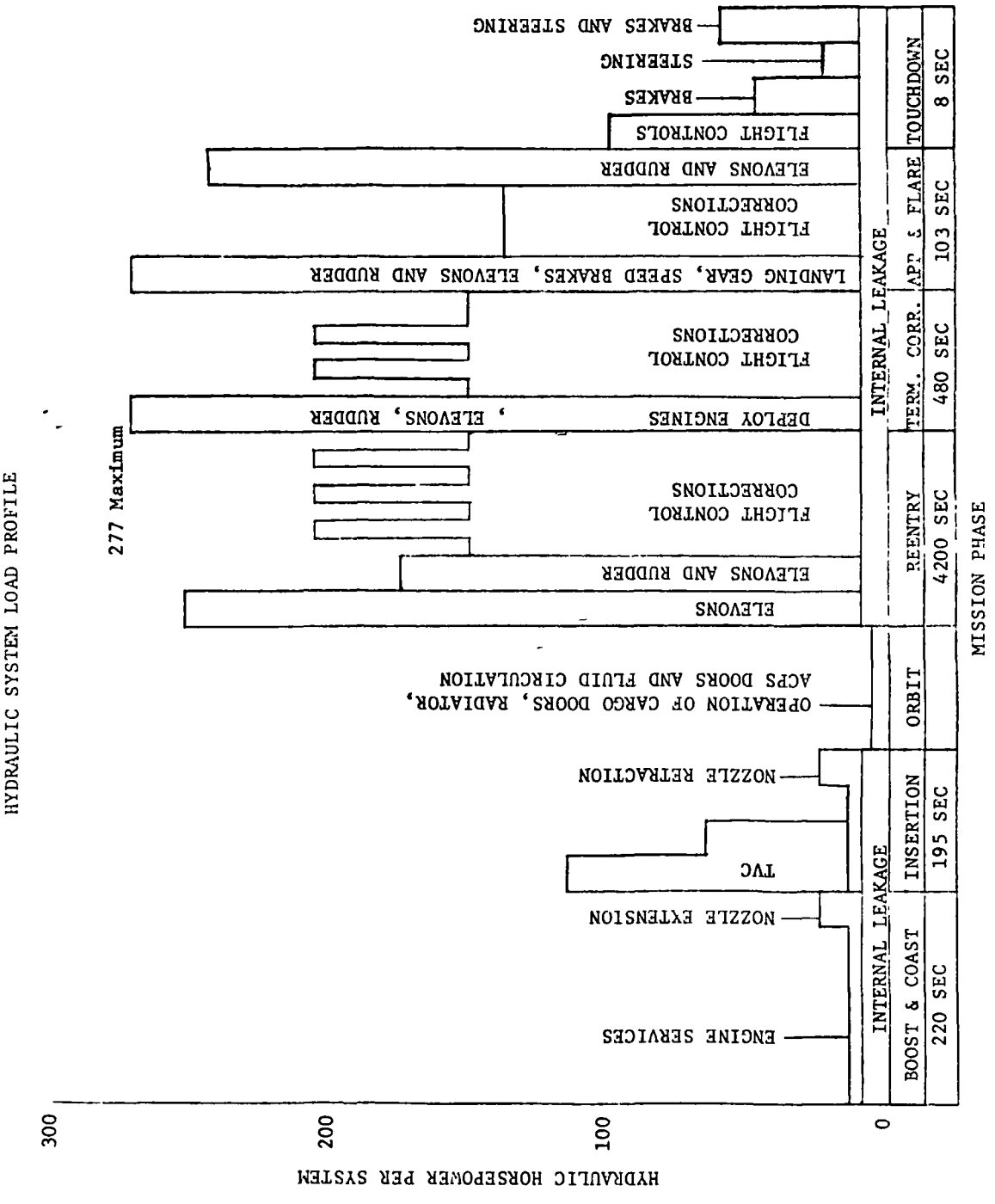
HYDRAULIC SYSTEM FUNCTIONAL DIAGRAM



WEIGHT SUBSTANTIATION

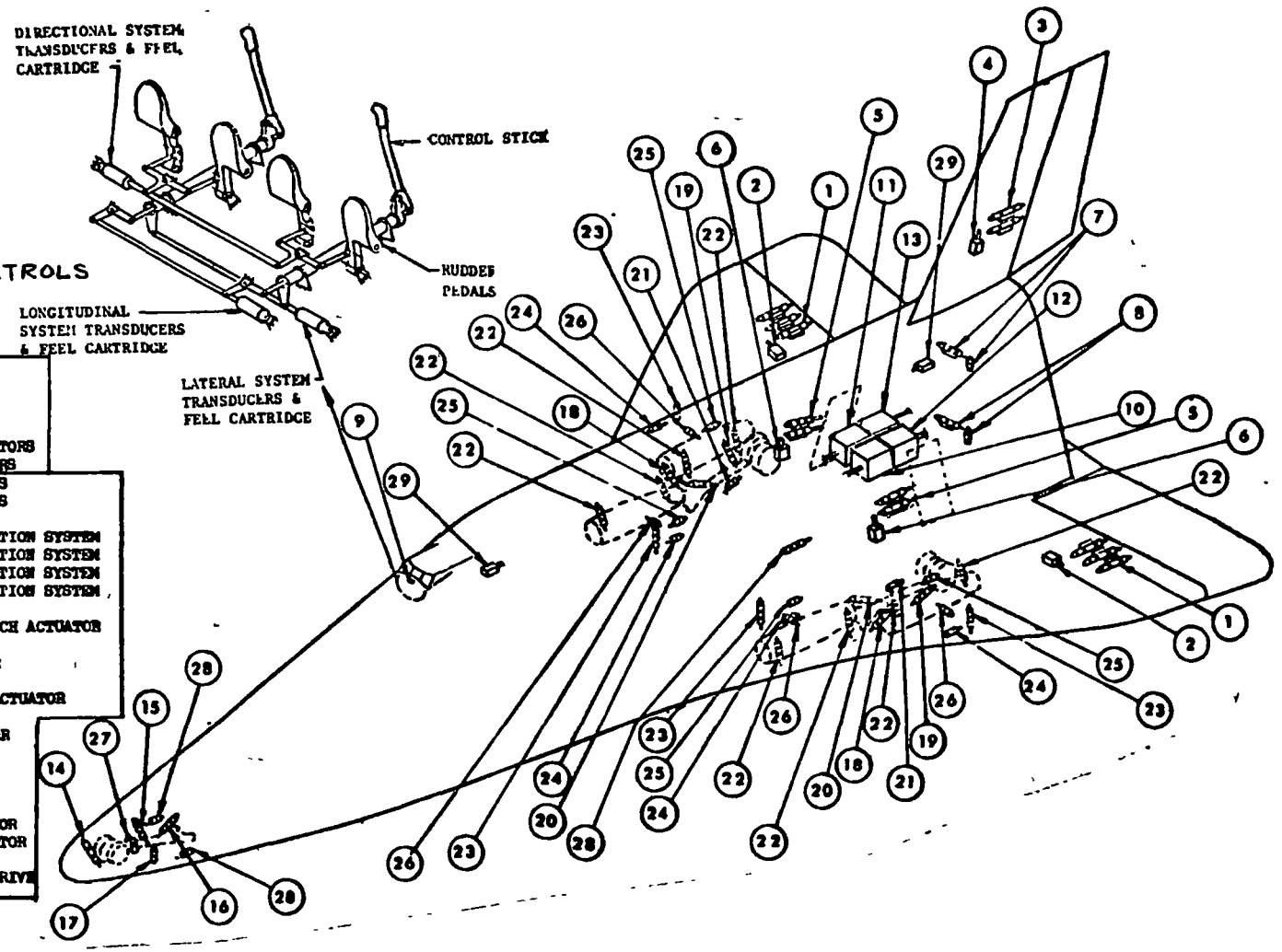
HYDRAULIC SYSTEM DESIGN PARAMETERS

FUNCTION	MAX. HINGE MOMENT (HM) (IN-LB)	DEFL (^{o})	RATE (^{o}SEC)	MAX. POWER PER SYS (H.P.)	HM AFTER 2 FALL. (%)
ELEVON	5.0×10^{6} per surface	+ 50 - 15	35	244	100
RUDDER	1.3×10^{6} per surface	$\pm$ 30	30	52	100
SPEED BRAKE	1.4×10^{6} per surface	+ 60	25	93	100
TVC	2.5×10^{6} per engine	$\pm$ 5.8 P $\pm$ 2.9 Y	10	98	100
ENGINE DEPLOYMENT	Free Fall (snubbing)	127 inbd 95 outbd	12.7 9.5	12.5	100
MAIN LANDING	$.358 \times 10^{6}$ per gear	101	20 down	40	100
NOSE LANDING GEAR	$.118 \times 10^{6}$ per gear	92.5	18.5 down	16.5	100
BRAKES	N/A	N/A	N/A	29	100
STEERING	$.160 \times 10^{6}$	$\pm$ 15	40	8.5	N/A
CARGO DOOR OR RADIATOR	$.48 \times 10^{6}$	180^{o}	2^{o}	2.8	100
ENGINE SERVICES	(DEPENDS ON ENGINE CONTRACTOR SELECTED)			15	N/A


HYDRAULIC SYSTEM LOAD PROFILE
277 Maximum
BRAKES AND STEERING
STEERING
BRAKES
FLIGHT CONTROLS
ELEVONS AND RUDDER
FLIGHT CONTROL CORRECTIONS
LANDING GEAR, SPEED BRAKES, ELEVONS AND RUDDER
FLIGHT CONTROL CORRECTIONS
DEPLOY ENGINES
, ELEVONS, RUDDER
FLIGHT CONTROL CORRECTIONS
ELEVONS AND RUDDER
ELEVONS
OPERATION OF CARGO DOORS, RADIATOR, ACPS DOORS AND FLUID CIRCULATION
NOZZLE RETRACTION
TVC
NOZZLE EXTENSION
ENGINE SERVICES
INTERNAL LEAKAGE
INTERNAL LEAKAGE
TOUCHDOWN
APP. & FLARE
TERM. CORR.
REENTRY
ORBIT
INSERTION
BOOST & COAST
8 SEC
103 SEC
480 SEC
4200 SEC
195 SEC
220 SEC
MISSION PHASE
300
200
100
0
HYDRAULIC HORSEPOWER PER SYSTEM

WEIGHT SUBSTANTIATION

HYDRAULIC EQUIPMENT LOCATION



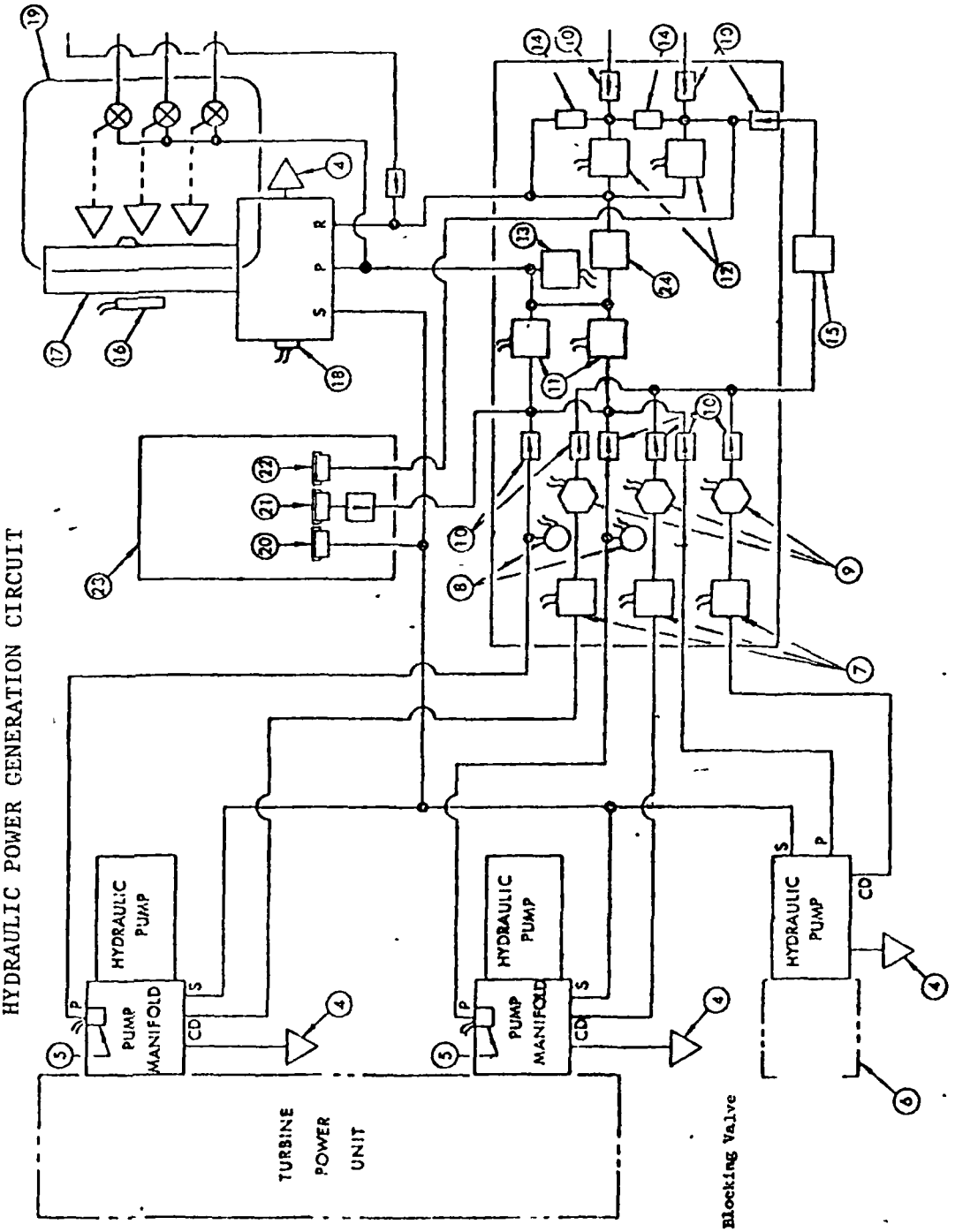
SECT 2.12 SURF CONTROLS

ITEM	COMPONENT
1	ELEVON SURFACE ACTUATORS
2	ELEVON SERVO ACTUATORS
3	RUDDER SURFACE ACTUATORS
4	RUDDER SERVO ACTUATOR
5	SPEED BRAKE SURFACE ACTUATORS
6	SPEED BRAKE SERVO ACTUATORS
7	UPPER ENGINE TVC ACTUATORS
8	LOWER ENGINE TVC ACTUATORS
9	HYDRAULIC CONTROL PANEL
10	ϕ1 HYDRAULIC POWER GENERATION SYSTEM
11	ϕ2 HYDRAULIC POWER GENERATION SYSTEM
12	ϕ3 HYDRAULIC POWER GENERATION SYSTEM
13	ϕ4 HYDRAULIC POWER GENERATION SYSTEM
14	N. G. DOOR ACTUATOR
15	N. G. DOOR AND GEAR UPLATCH ACTUATOR
16	N. G. ACTUATOR
17	N. G. DOOR LATCH ACTUATOR
18	M.L.G. DOOR ACTUATOR
19	M.L.G. DOOR AND UPLATCH ACTUATOR
20	M.L.G. ACTUATOR
21	M.L.G. DOOR LATCH ACTUATOR
22	ENGINE DOOR ACTUATOR
23	ENGINE ACTUATOR
24	ENGINE DOWN LOCK ACTUATOR
25	ELGINE UP LOCK ACTUATOR
26	ENGINE DOOR UPLOCK ACTUATOR
27	NOSE WHEEL STEERING ACTUATOR
28	ACTS DOOR ACTUATOR
29	CARGO DOOR AND RADIATOR DRIVE

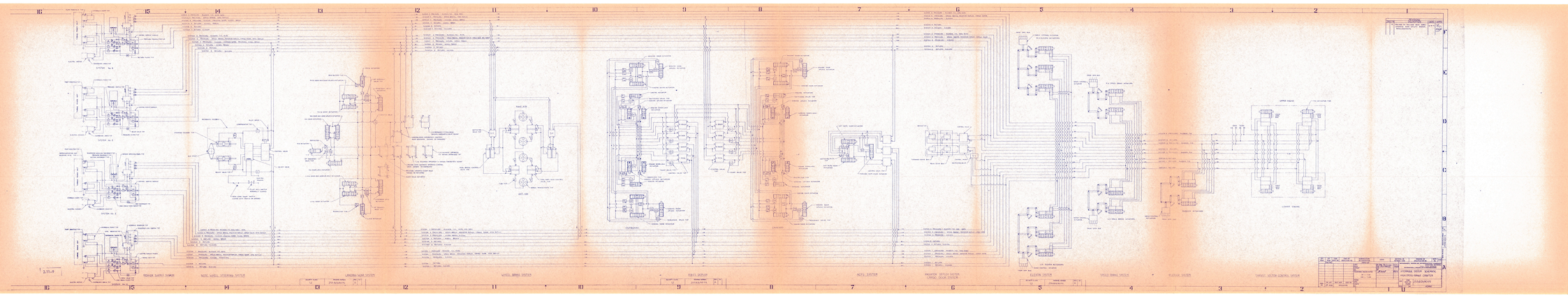
SECT. 2.11 HYDRAULIC

WEIGHT SUBSTANTIATION

HYDRAULIC POWER GENERATION CIRCUIT



ITEM	COMPONENT
1	Turbine Power Unit
2	Pump Manifold
3	Hydraulic Pump
4	Overboard Drain
5	Depressurization and Blocking Valve
6	Electric Motor
7	Case Drain Filter
8	Pressure Switch
9	Case Drain Flowmeter
10	Check Valve
11	Pressure Filter
12	Return Filter
13	Pressure Transmitter
14	By Pass Valve
15	Heat Exchanger
16	Level Indicator
17	Hydraulic Reservoir
18	Temperature Sensor
19	Reservoir Level Sensor
20	Suction Disconnect
21	Pressure Disconnect
22	Reservoir Servicing Disconnect
23	Ground Service Panel
24	Relief Valve


POWER SUPPLY SYSTEM
NOSE WHEEL STEERING SYSTEM
MAIN GEAR SYSTEM
WHEEL BRAKE SYSTEM
FUEL SYSTEM
MPS SYSTEM
PNEUMATIC SYSTEM
HYDRAULIC SYSTEM
FLIGHT CONTROL SYSTEM
ELEVON SYSTEM
RUDDER SYSTEM
SPEED BRAKE SYSTEM
BODY FLAP SYSTEM
TARGET SECTION CONTROL SYSTEM
ELECTRICAL SYSTEM SCHEMATIC
MAIN CONTROL SYSTEM SCHEMATIC
2.11-9

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WEIGHT SUBSTANTIATION

HYDRAULIC FLUID (CODED IN SECT 2.23)

WEIGHT INVENTORY

ITEM	NOTES	UNIT WT. LB.	QTY.	FLUID TOT. WT. LB.
TOTAL PRESSURE LINES	[1]			178.83
TOTAL RETURN LINES	[1]			181.11
SUBTOTAL LINES		89.99 (AVG/SYS)	4	(359.94)
ACTUATORS, ETC.				
ELEVON	[2]	3288	6	197.28
RUDDER	[2]	13.00	2	26.00
SP. BRAKE	[2]	14.00	4	56.00
THRUST VECTOR CONTROL (TVC)		5.25	4	21.00
ENGINE DEPLOY (ABES)		2.99	4	11.96
DOOR (ABES)		7.17	4	28.56
ACPS DOOR (EST)		1.00	3	3.00
FLIPPER DOOR (ABES)		.58	4	2.32
RADIATOR/CARGO DOOR (EST)		1.00	2	2.00
MAIN GEAR ($438\ IN^3 \times .03\ LB/IN^3$)	[3]	13.14	2	26.28
NOSE GEAR ($181\ IN^3 \times .03\ LB/IN^3$)	[3]	5.43	1	5.43
STEERING ($120\ IN^3 \times .03\ LB/IN^3$)	[3]	3.60	1	3.60
BRAKES ($6\ IN^3 \times .03\ LB/IN^3$)	[3]	.18	2	.36
PRIMARY PUMPS (EST)		8.0	8	64.00
SECONDARY PUMPS (EST)		4.0	4	16.00
SUBTOTAL ACTUATORS, ETC		115.95 (AVG/SYS)	4	(463.79)

[1] SEE PAGE 2.11-18 FOR DETAIL ANALYSIS
[2] SEE SECT. 2.12 FOR FLUID WEIGHT COMPUTER CALC.
[3] SEE SECT. 2.5 FOR LANDING GEAR SYSTEMS.

WEIGHT SUBSTANTIATION

HYDRAULIC FLUID WEIGHT INVENTORY
AND RESERVOIR SIZING
(FLUID WT. CODED IN SECT 2.23)

FROM PAGE 2.11-12

TOTAL HYDRAULIC FLUID/SYSTEM = 89.99 (LINES)
+ 115.95 (ACTUATORS)

= 205.94 LB./SYS.

VOLUME/SYSTEM = $\frac{205.94 \text{ LB}}{.03 \text{ LB/IN}^3}$ = 6864.58 IN^3

ESTIMATED FLUID EXPANSION = .257 × 6864.58
(REFERENCE PAGE 2.11-25)
= 1764.20 IN^3

LANDING GEAR DIFFERENTIAL
VOLUME EST. @ 10% (438 IN^3 × 2 + 181 IN^3) = 105.70 IN^3

SUBTOTAL RESERVOIR VOLUME 1869.90 IN^3

ADD 25% HI-LOW MARGIN 467.47

TOTAL RESEVOIR VOLUME/SYS. 2337.37 IN^3
231 IN^3/GAL ∴ VOL. = 10.12 GAL

∴ USE DC-10 UTILITY RESERVOIR (12.2 GAL)

UNIT WT. = 58.3 LB EA × 4 REQ'D (DRY)

ASSUME NOMINAL RESERVOIR FLUID WT.

= 12.2 GAL × 231 IN^3 × .03 #/IN^3 × 50%

= 42.27 LB/RESERVOIR × 4 REQ'D.

WEIGHT SUBTANTIATION

HYDRAULIC FLUID
WEIGHT SUMMARY

PRESSURE & RETURN LINES	360
ACTUATORS, PUMPS, ETC.	464
RESERVOIRS 42.3 x 4 REQ'D	169
CONTINGENCY ~ 9.5%	94
TOTAL FLUID	1087 LB

NOT CODED IN SECT 2.11 DRY WEIGHT

SEE SECT. 2.23 RESIDUAL FLUIDS.

WEIGHT SUBSTANTIATION

DISTR. & CONTROL CENTER

SERVICE ITEMS VALVES & CONTROLS

ITEM	UNIT WT	QTY.	TOTAL WEIGHT
ENGINE DEPLOY (ABES)			(73)
4-WAY 3 POS VALVE (ELEC.)	10	2	20
1-WAY 3 POS VALVE (ELEC.)	5	2	10
2-WAY 3 POS VALVE (ELEC.)	10	2	20
SWITCHING VALVE	1	10	10
SEQUENCING VALVE	1	4	4
RESTRICTOR	0.5	18	9
LANDING GEAR			
3-WAY 2 POS VALVE (ELEC.)	10	2	20
4-WAY 3 POS VALVE (ELEC.)	10	1	10
DUMP VALVE	5	1	5
MAIN GEAR			
SEQUENCING VALVE (ELEC.)	1	4	4
RESTRICTOR	0.5	4	2
NOSE GEAR			
SEQUENCING VALVE (ELEC)	1	2	2
RESTRICTOR	0.5	1	0.5
STEERING			
CONTROL VALVE (ELEC.)	10	1	10
ON-OFF VALVE (ELEC.)	5	1	5
RELIEF VALVE	0 5	2	1
MAIN GEAR BRAKES			
SWITCHING VALVE	1	2	2
CONTROL VALVES (INCLD. WITH L.G. SYS)		6	N/A
ACPS DOORS			
CONROL VALVE (ELEC.)	3	3	9
SWITCHING VALVE	1	6	6

WEIGHT SUBSTANTIATION

DISTR. & CONTROL CENTER - CONT.

SERVICE ITEMS VALVES & CONTROLS

ITEM	UNIT WT.	QTY.	TOTAL WEIGHT
CARGO DOOR			
CONTROL VALVE (ELEC.)	3	3	9
SWITCHING VALVE	1	2	2
(AVG/SYS)	40.13	4	
TOTAL VALVE & CONTROLS (SERV. ITEMS)			160.5

WEIGHT SUBSTANTIATION

CIRCUITRY FOR SERVICE ITEMS

CIRC. UNIT WT. = 4 LB/1000 FT × 4 PICK-UAS/VALUE × 1.50 INSTL
= .024 LB/FT

	ROUTING LENGTH FT.	NO. OF VALUES (REF. PG. 2.11-15)	TOTAL WEIGHT
ENGINE OBPLOY	63	10	15.12
LANDING GEAR - MAIN	63	7	10.58
- NOSE	184	2	8.83
NOSE WH STEERING	184	2	8.83
WHEEL BRAKES	75	6	10.80
CARGO DOOR	78	3	5.62
ACPS DOOR	156	3	11.23
	17.75 (AVG/SYS)	4	
SUBTOTAL DIST. CONTROL CENTER			(71.01 LB)

WEIGHT SUBSTANTIATION

HYDRAULIC SYSTEM
WEIGHT CALCULATION
PLUMBING WEIGHT SUMMARY

	PRESSURE LINES – TITANIUM							RETURN LINES – ALUMINUM						
	① LENGTH FT	② QTY	③ TUBE'S FTG WT #/FT	④ TOTAL TUBE'S FTGS LB	⑤ FLUID WT #/FT	⑥ TOTAL FLUID WT LB	TOTAL WT TUBE+FLUID LB	① LENGTH FT	② QTY	③ TUBE'S FTG WT #/FT	④ TOTAL TUBE'S FTGS LB	⑤ FLUID WT #/FT	⑥ TOTAL FLUID WT LB	TOTAL WT TUBE+FLUID LB
FLEXIBLE HOSE FWD	13	4	.1849	9 61	.1308	6 80	16 41	13	4	0922	4 79	1362	7 08	11 87
[illegible] -LINE	44	8	1849	65 08 *	.1308	46 08	111.16	44	8	.0922	32 45 *	1362	47 94	80.39
RUDDER	56	4	1526	34 18 *	0871	19 51	53 69	56	4	.0605	13.55 *	0954	21.37	34.92
SPEED BRAKE	13	8	.0424	4 41 *	.0333	3 46	7 87	13	8	.0317	3 30 *	0317	3 30	6 60
RVC-OMS	45	3	1849	24 96 **	.1308	17 66	42 62	45	3	.0922	12.45 **	1362	18.39	30 84
[illegible] R	30	3	1526	13 73 **	.0871	7 84	21.57	30	3	0605	5 45 **	0954	8.59	14 04
ENGINE DEMOY	63	12	0348	26.31	.0222	16.78	43 09	63	12	.0317	23 97	0317	23.97	47 94
[illegible]-MAIN	63	6	.0979	37.01	.0557	21 05	58.06	63	2	.0432	5.44	0598	7 53	12 97
- NOSE	184	1	0613	11.28	0447	8 22	19.50	184	1	.0374	6 88	0447	8.22	15.10
NOSE WH STEERING	184	2	0218	8 02	0222	8.17	16.19	184	2	0317	11 67	0317	11 67	23 34
[illegible] GR. BRAKE	75	6	.0613	27.59	0447	20.12	47 71	75	6	0374	16.83	0447	20.12	36.95
CARGO DOOR	78	1	0282	2.20	0134	1 05	3 25	78	1	0202	1 58	.0125	.98	2 56
AERO BRAKE	156	1	0282	4.40	0134	2.09	6 49	156	1	0202	3.15	.0125	1 95	5 10
TOTALS				268.78		178 83	447.61				141.51		181 11	322.62
* ADD'D IN SURFACE CONTROLS														
** INCL'D IN MAIN PROPULSION														
TOTALS W/O (* & **)				126.42	(AVG/SYS = $\frac{126.42}{4}$) = 31.61 LB						74.31	(AVG/SYS = $\frac{74.31}{4}$) = 18 58 LB		

[illegible] FROM PAGE 2.11-20

[illegible] TO PAGE 2.11-21

WEIGHT SUBSTANTIATION

2.11 HYDRAULIC TEMPERATURE CONTROL SYSTEM

CRYO H_2 H.X. FOR 101,000 BTU/85 MIN.

UNIT WT = 60 LB/SYS. *

CONTROL VALVE (1)/H.X	= 1.7
TEMP SENSOR (1)/H.X.	= .1
CONTROLLER (1)/H.X	= 1.5

TOTAL VALVES & CONTROLS 3.3 LB/SYS.

PLUMBING & MISC. EST. @ 8.0 LB/SYS.

TOTAL TEMP CONTROL SYS. 71.3 LB/SYS

NOTE: EST. CRYO H_2 CONSUMPTION IS:

$$\frac{101{,}000\ \text{BTU}}{1500\ \text{BTU/LB}} = 67.4\ \text{LB}\ H_2/\text{SYS.}$$

THIS H_2 IS ASSUMED AVAILABLE FROM PRESENT HYDROGEN BOIL-OFF ALLOWANCES. REFERENCE SECT. 2.26 INFLIGHT LOSSES.

* FROM O-EAST-ECLS-1

WEIGHT SUBSTANTIATION

HYDRAULIC SYSTEM
WEIGHT CALCULATION
PRESSURE & RETURN LINES

ITEM	LENGTH (1) FT	QTY	HP (MAX LINE)	ΔP PSI	ΔP/L PSI/FT	FLOW GPM (2)	(6) PRESSURE LINES – TITANIUM OD IN	WALL IN (3)	UNIT WT LB/FT (4)	FIG'S 20% TUBE WT/FT	TUBE WT/FT IN³/FT	FLUID WT #/FT @ 3000 PSI/IN³ (2)	TOTAL WT #/FT (4)+(5)+(3)	(6) OD IN	RETURN LINES – ALUM WALL IN (5)	UNIT WT LB/FT (1)	FIG'S 20% TUBE WT/FT	TUBE WT/FT IN³/FT	FLUID WT #/FT @ 65 PSI	TOTAL WT #/FT
FLT INSTRUMENTS	13	4	268 28	500	38 46	153 3	3/4	.035	1541	0308	4 3584	.1308	3157	3/4	028	0768	0154	4 0396	1302	2284
ELEVON LINE	44	8	13, 14	500	11 36	76 65	3/4	035	.1541	.0308	4 3554	1308	.3157	3/4	028	0768	0154	4 5396	1302	.2284
RUDDER	56	4	98 48	1000	17.86	56 24	5/8	.035	1272	0254	2 9028	0871	2397	5/8	022	0504	.0101	3 1812	0754	.1559
SPEED BRAKE	13	8	44 19		7692	25 25	3/8	.016	0353	.0071	1.1028	.0333	0757	3/8	020	0264	.0053	1 0572	0317	0634
TVC – UPR	45	3	140		22 22	80.0	3/4	035	1541	0308	4 3584	.1308	.3157	3/4	028	0768	.0154	4.5396	.1362	2284
TVC – LWR	30	3	140		33.33	60.0	5/8	035	1272	.0254	2 9028	0871	.2397	5/8	.022	0504	0101	3 1812	0754	1559
FWD RCS DEPLOY	63	12	12.5		15 87	7 14	5/16	.016	.0290	0058	7416	0222	.0570	3/8	.020	0264	.0053	1 0572	0317	0634
LWR RCS MAN	63	6	40		15 87	22 86	1/2	028	0816	.0163	1 9576	.0557	.1536	1/2	020	0360	0072	1 9944	.0598	.1030
[illegible] NOSE	194	1	10.5		5 43	9 43	7/16	020	.0511	0102	1 4892	.0447	.1060	7/16	020	.0312	0062	1 4392	0447	0821
EST IN STEERAG	184	2	8.5		5.43	4 86	5/16	016	0290	0058	7416	0222	.0570	3/8	.020	.0264	0053	1 0572	0317	0634
MAIN GR LANDG	75	6	240		13.33	16 57	7/16	020	0511	0102	1 4892	0447	1060	7/16	.020	0312	.0062	1 4392	0447	0821
CARGO DOOR	78	1	28		12 82	16	1/4	016	0235	0047	4476	0134	0416	1/4	.020	0168	0034	.4152	0125	.0327
AFT BULK	156	1	28	V	6 41	16	1/4	016	0235	.0047	4476	.0134	.0416	1/4	020	0163	.0034	4 52	0125	0327

(1) SEE PAGE 2.11-21 FOR LINE ℓ CALCULATION (INCLUDES 50% ROUTING ALLOWANCE)

(2) GPM = $\frac{HP \times 1714.29}{3000\ PSI}$

(3) TITANIUM MINIMUM WALL THICKNESS IS .016 IN. REF. PAGE 2.11-24

(4) TITANIUM UNIT WEIGHT (LB/FT) = STEEL UNIT WT (LB/IN) × 12 IN/FT × $\frac{163\ LB/IN^3}{283\ LB/IN^3}$

STEEL UNIT WT. (LB/IN) = 6 9117 REF. PAGE 2.11-24

(5) ALUMINUM MINIMUM WALL THICKNESS IS .020 IN. REF. PAGE 2.11-23

(6) PRESSURE AND RETURN LINE OD FROM PAGE 2.11-22 BASED ON THE $\frac{\Delta P}{\ell}$ AND FLOW VALUES. OUTER LINE SIZE IS SIMILAR EQUAL TO OR GREATER THAN INNER LINE SIZE.

WEIGHT SUBSTANTIATION

HYDRAULIC SYSTEM
PLUMBING LENGHTS/UNIT

ITEM	① ℓ IN	② ℓ + 50% FOR ROUTING IN	③/12 FT.	QTY
ELEVON - MANIFOLD	100	150	13	4
- LINE	350	525	44	8
RUDDER	450	675	56	4
SPEED BRAKE	100	150	13	8
TVC ~ UPR	360	540	45	3
TVC ~ LWR	240	360	30	3
ENG DEPLOY	500	750	63	12
LAND. GR. ~ MAIN	500	750	63	6
~ NOSE	1470	2205	184	1
WHEEL BRAKES	600	900	75	6
CARGO DOOR	625	937.5	78	1
ACPS DOOR	1250	1875	156	1
STEL RING	1470	2205	184	2

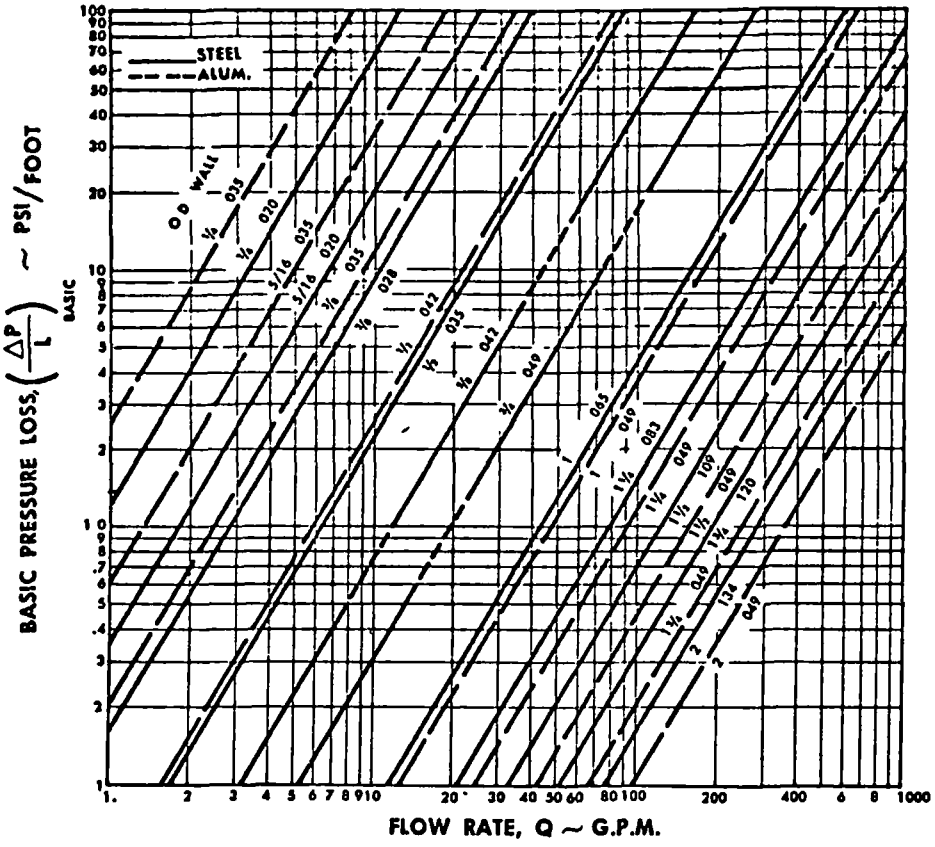
WEIGHT SUBSTANTIATION

PRESSURE LOSS IN HYDRAULIC LINES

MIL-O 5606 ~ T = 180°F

TURBULENT FLOW

$$\frac{\Delta P}{L} = 9.15 \times 10^{6} \left(\rho v^{2.5}\right)_{FLUID} \left(\frac{1}{D^{4.75}}\right)_{LINE} \left(Q^{1.75}\right)_{FLOW} \qquad \left(\rho v^{2.5} = 79.1\right)$$



Capacity of Tubing Cubic Inches Per Inch

OD	Wall Thickness															
	016	020	022	028	035	042	049	058	065	083	095	109	120	156	188	250
3 16	0190	0171	0162	0137	0108	0084	0063	0040	0026	0004						
1/4	0373	0346	0333	0296	0254	0216	0182	0141	0113	0055	0028	0008				
5 16	0618	0583	0566	0517	0462	0410	0361	0303	0262	0169	0118	0070	0041			
3 8	0924	0881	0861	0799	0731	0665	0603	0527	0471	0343	0269	0194	0143	0031		
7 16	1292	1241	1216	1143	1061	0981	0905	0812	0743	0579	0481	0378	0306	0124	0030	
1 2	1720	1662	1633	1548	1452	1359	1269	1158	1075	0876	0755	0625	0531	0278	0121	
9 16	22 1			2015	1905	1793	1695	1566	1469	1235	1090	0933	0817	0493	0273	0031
5 8	2762	2688	2651	2543	2419	2299	2181	2030	1924	1655	1486	1301	1164	0759	0437	0113
3 4	4049	3959	3915	3783	3632	3484	3339	3157	3019	2679	2463	2223	2043	1507	1099	0491
7 8	5581	5476	5424	5268	5090	4914	4742	4525	4359	3949	3685	3390	3167	2439	1956	1104
1	7359	7238	7178	6999	6793	6590	6390	6138	5945	5463	5153	4803	4537	3718	3058	1963
1 1 8	9381	9245	9177	8973	8742	8511	8282	7996	7776	7223	6866	6461	6151	5191	4406	3068
1 1 4	1 165	1 150	1 142	1 120	1 094	1 068	1 042	1 010	9852	9228	8824	8364	8012	6912	5999	4418
1 3 8	1 416	1 400	1 391	1 366	1 338	1 309	1 281	1 245	1 217	1 148	1 103	1 051	1 012	8875	7838	6013
1 1 2	1 692	1 674	1 665	1 638	1 606	1 575	1 544	1 504	1 474	1 377	1 348	1 291	1 247	1 108	9924	7854
1 5 8	1 994	1 974	1 964	1 934	1 899	1 865	1 832	1 789	1 756	1 672	1 618	1 554	1 507	1 354	1 225	9941
1 3 4	2 319	2 297	2 286	2 254	2 217	2 180	2 143	2 097	2 061	1 971	1 911	1 844	1 791	1 624	1 483	1 227
1 7 8	2 668	2 645	2 633	2 599	2 559	2 519	2 480	2 430	2 392	2 294	2 230	2 156	2 100	1 919	1.765	1 485
2	3 042	3 017	3 005	2 968	2 926	2 883	2 841	2 788	2 746	2 642	2 573	2 494	2 433	2 238	2 071	1 767
2 1 4	3 864	3 836	3 822	3 781	3 733	3 684	3 638	3 577	3 530	3 411	3 333	3 243	3 173	2 950	2 758	2 405
2 1 2	4 784	4 753	4 737	4 691	4 638	4 585	4 532	4 464	4 412	4 279	4 191	4 090	4 011	3 760	3 543	3 142
2 3 4		5 768	5 751	5 700	5 641	5 582	5 523	5 449	5 391	5 248	5 157	5 055	4 968	4 668	4 427	3 976

WEIGHT SUBSTANTIATION

ALUMINUM ALLOY (6061T6) TUBING FOR RETURN LINES

3000 PSI OPERATING t = .035D
4000 PSI OPERATING t = .046D

FOR HANDLING - .016 WALL THICKNESS IS MINIMUM USED.
NOTE! → .020 " " " " " HERE.

SYSTEM PRESSURE	TUBE O.D.	WALL (INCHES)	WEIGHT EMPTY (LB/FT)	WEIGHT FULL (LB/FT)	MIN WALL
3000	.250	.016	.0144	.0276	.009
4000		.016	.0144	.0276	.012
3000	.3125	.016	.0180	.0408	.011
4000		.016	.0180	.0408	.015
3000	.375	.016	.0216	.0552	.013
4000		.018	.0240	.0570	.017
3000	.4375	.016	.0252	.0720	.015
4000		.020	.0312	.0768	.020
3000	.500	.018	.0288	.0910	.018
4000		.025	.0444	.1020	.023
3000	.5625	.020	.0408	.1188	.020
4000		.028	.0576	.1308	.026
3000	.625	.022	.0456	.1428	.022
4000		.035	.0780	.1656	.029
3000	.750	.026	.0708	.2100	.026
4000		.035	.0948	.2268	.035
3000	.875	.032	.1020	.2892	.031
4000		.042	.1320	.3108	.041
3000	1.000	.035	.1272	.3744	.035
4000		.049	.1752	.4080	.046

Alluminum Alloy Tubing (lb/In)

OD	Wall Thickness															
	016	020	022	028	035	042	049	058	065	083	095	109	120	156	188	250
3 16		0011	0011	0014	0017	00 9	0021	0024	0025	0027						
1 4		0014	0016	0020	0024	0027	0031	0035	0038	0044	0046	0048	0049			
5 16		0018	0020	0025	0031	0036	0041	0046	0051	0060	0065	0070	0073			
3 8		0022	0024	0031	0037	0044	0050	0058	0063	0076	0084	0091	0096			
7 16		0026	0029	0036	0044	0052	0060	0069	0076	0092	0102	0113	0120	0138		
1 2		0033	0033	0042	0051	0060	0069	0081	0089	0109	0121	0134	0143	0169		
9 16		0034	0037	0047	0058	0069	0079	0092	0102	0125	0140	0155	0167	0199	0211	
5 8		0038	0042	0053	0065	0077	0089	0103	0114	0141	0158	0177	0190	0230	0258	
3 4		0046	0050	0064	0079	0093	0108	0126	0140	0174	0196	0220	0238	0291	0332	0393
7 8		0054	0059	0075	0092	0110	0127	0149	0165	0207	0233	0262	0285	0352	0406	0491
1		0062	0068	0086	0106	0126	0146	0172	0191	0239	0270	0305	0332	0414	0480	0589
1 1 8		0069	0076	0097	0120	0143	0166	0194	0216	0272	0307	0348	0379	0475	0553	0687
1 1 4		0077	0085	0108	0134	0159	0185	0217	0242	0304	0345	0391	0426	0536	0627	0785
1 3 8		0085	0094	0118	0147	0176	0204	0240	0268	0337	0382	0434	0473	0597	0701	0884
1 1 2		0094	0102	0130	0161	0192	0223	0263	0293	0370	0419	0476	0520	0659	0775	0982
1 5 8		0102	0111	0141	0175	0209	0243	0286	0319	0402	0457	0519	0567	0720	0849	1080
1 3/4		0110	0119	0152	0189	0225	0262	0308	0344	0435	0494	0562	0615	0781	0923	1178
1 7 8		0118	0128	0163	0202	0242	0281	0331	0370	0467	0531	0605	0662	0843	0996	1276
2		0125	0137	0174	0216	0258	0300	0354	0395	0500	0569	0648	0709	0904	1070	1375
2 1 4		0141	0155	0196	0244	0291	0339	0399	0446	0565	0643	0733	0803	1026	1218	1571
2 1 2		0157	0173	0217	0271	0324	0377	0445	0497	0630	0718	0819	0897	1149	1366	1767
2 3 4		0173	0192	0239	0299	0357	0416	0491	0548	0695	0792	0904	0992	1271	1513	1964

WEIGHT SUBSTANTIATION

TITANIUM ALLOY (6AL-4V) TUBING FOR PRESSURE LINES

3000 PSI OPERATING $t = 0.045D$
4000 PSI OPERATING $t = 0.06\ D$

FOR HANDLING - .016 WALL THICKNESS IS MINIMUM USED.

SYSTEM PRESSURE	TUBE O.D.	WALL (INCHES)	WEIGHT EMPTY (LB/FT)	WEIGHT FULL (LB/FT)	MIN WALL
3000	.250	.016	.0228	.0372	.011
4000		.016	.0228	.0372	.015
3000	.3125	.016	.0283	.0516	.014
4000		.020	.0360	.0577	.019
3000	.375	.016	.0360	.0695	.017
4000		.024	.0516	.0830	.023
3000	.438	.020	.0516	.0970	.020
4000		.026	.0660	.1180	.027
3000	.500	.024	.0708	.1282	.023
4000		.032	.0914	.1468	.030
3000	.562	.026	.0865	.1610	.026
4000		.035	.1140	.1835	.034
3000	.625	.032	.1175	.2075	.029
4000		.038	.1380	.2240	.038
3000	.750	.035	.1545	.2870	.034
4000		.049	.2120	.3340	.046
3000	.875	.039	.2020	.3830	.040
4000		.052	.2640	.4350	.053
3000	1.000	.049	.2880	.5200	.045
4000		.065	.3760	.5910	.060
3000	1.125	.052	.3440	.6430	.051
4000		.072	.4690	.7440	.068

STEEL TUBING (LB/IN) x 12 IN/FT x $\frac{.163\ LB/IN^3}{.283\ LB/IN^3}$ = TITANIUM (LB/FT)

Steel Tubing (Lb/in)

OD Inches	Wall Thickness – Inches															
	016	020	022	028	035	042	049	058	065	083	095	109	120	156	188	250
3 16	0024	0030	0032	0040	0048	0055	0061									
1 4	0034	0041	0045	0055	0067	0078	0088	0099	0107							
5 16	0042	0052	0057	0071	0087	0101	0115	0132	0143	0170	0184	0198				
3 8	0051	0063	0069	0087	0106	0125	0142	0164	0180	0216	0237	0259	0273	0305		
7 16	0060	0074	0082	0102	0126	0148	0170	0196	0216	0263	0290	0320	0340	0392	0418	
1 2	0069	0085	0094	0118	0145	0172	0197	0229	0252	0309	0343	0380	0407	0479	0523	
9 16	0077	0097	0106	0133	0165	0195	0225	0261	0288	0355	0396	0441	0474	0566	0628	
5 8	0087	0108	0118	0149	0184	0218	0252	0293	0325	0401	0449	0502	0541	0653	0733	
3 4	0105	0130	0143	0180	0223	0265	0306	0358	0397	0494	0555	0623	0674	0827	0943	1115
7 8	0123	0153	0167	0212	0262	0312	0361	0423	0470	0586	0661	0745	0808	1001	1152	1394
1	0141	0175	0192	0243	0301	0359	0416	0487	0542	0679	0767	0866	0942	1175	1362	1673
1 1 8	0159	0197	0217	0275	0341	0407	0471	0554	0595	0772	0873	0988	1076	1349	1572	1952
1 1 4	0176	0219	0242	0304	0378	0458	0523	0614	0687	0864	0980	1110	1210	1523	1781	2231
1 3 8	0196	0243	0267	0338	0418	0500	0580	0682	0760	0957	1095	1231	1344	1697	1991	2509
1 1 2	0212	0264	0297	0361	0457	0546	0634	0746	0832	1049	1191	1353	1477	1871	2201	2788
1 5 8	0228	0285	0314	0399	0497	0593	0689	0811	0905	1142	1297	1474	1611	2045	2410	3067
1 3 4	0246	0308	0338	0430	0536	0640	0744	0876	0977	1235	1403	1596	1745	2219	2620	3346
1 7 8	0765	0331	0364	0460	0575	0687	0798	0940	1050	1327	1509	1718	1879	2393	2830	3625
2	0283	0354	0389	0493	0613	0734	0853	1005	1122	1420	1615	1839	2013	2567	3039	3903
2 1 4	0308	0398	0438	0554	0690	0831	0962	1134	1267	1605	1827	2082	2281	2915	3459	4461
2 1/2	0354	0442	0486	0618	0769	0929	1072	1264	1412	1790	2039	2325	2548	3263	3878	5019
2 3/4	0390	0487	0535	0680	0848	1015	1181	1393	1557	1975	2250	2568	2816	3610	4297	5576

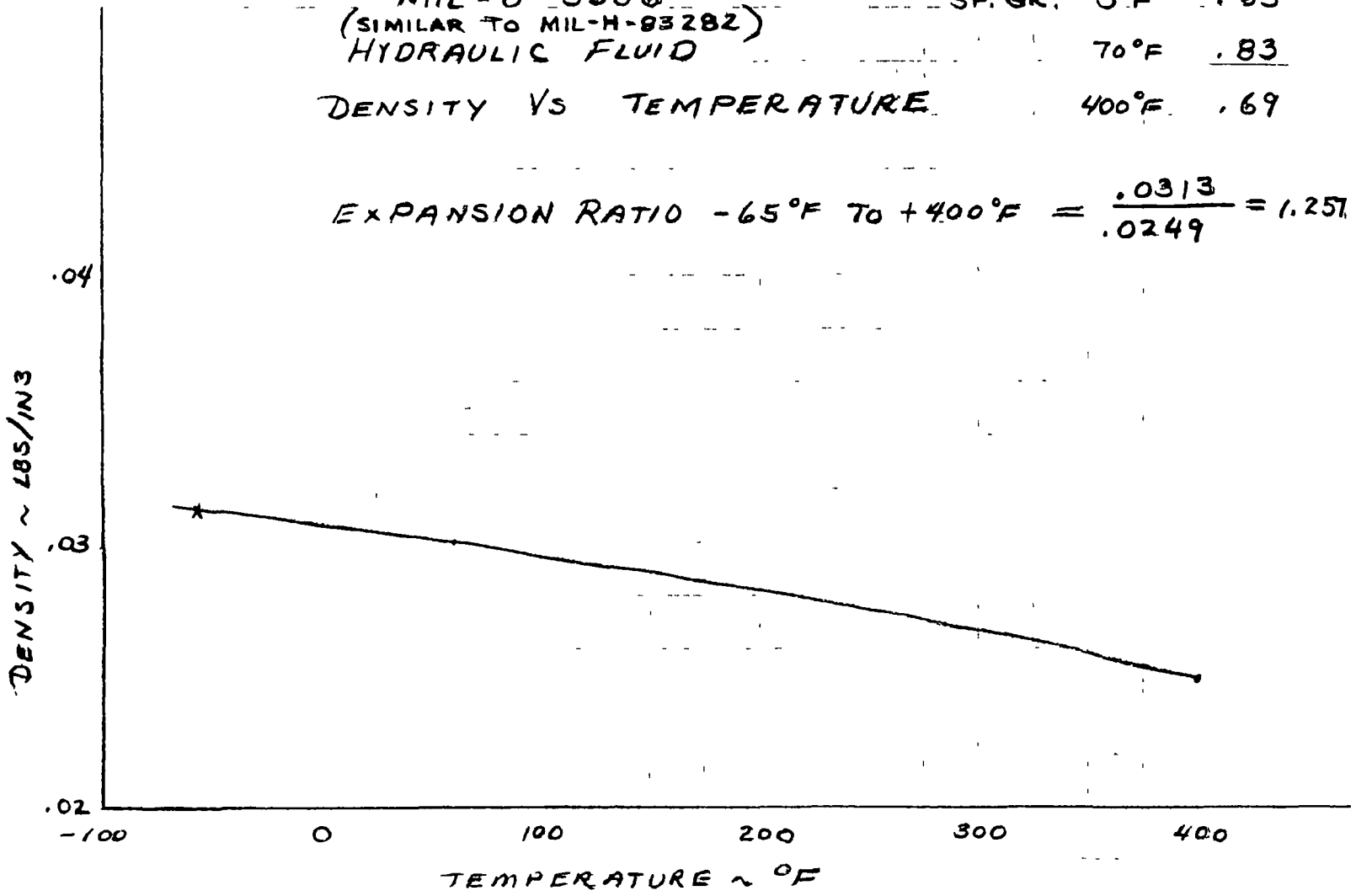
WEIGHT SUBSTANTIATION

MIL-O-5606 (SIMILAR TO MIL-H-83282) HYDRAULIC FLUID

DENSITY VS TEMPERATURE

	SP. GR.
0°F	.85
70°F	.83
400°F	.69

EXPANSION RATIO -65°F TO +400°F $= \frac{.0313}{.0249} = 1.257$



2.11 HYDRAULIC

LIST OF REFERENCES & DATA SOURCES

1. MAIN HYDRAULIC PUMP UNIT WT = 40LB. FROM ABEX CORP. MODEL AP27V-1 MODIFIED FROM GRUMMAN F-14 EDP DESIGN. MAX CIPR = 4.4, RATED SPEED = 5500 RPM, MAX FLOW @ RATED SPEED = 98 GPM, 3000PSI, VARIABLE DISPLACEMENT, STEEL HOUSING, MAX DESIGN TEMP. = 350°F.
2. RESERVOIR ~ REFEERENCE PAGE 2.11-13 UNIT WT. = 58.3 LB FOR 12.2 GAL CAPACITY DC-10 UTILITY RESERVOIR, PART NO. AYG 7027.
3. PUMP MANIFOLD UNIT WT EST. @ 47.2 LB. BASED ON TWO TIMES WT. OF F-15 UTILITY MANIFOLD, PART NO. 68-690082, UNIT WT = 23.6 LB.
4. EDV & RLS BASED ON COMPARABLE F-4 EQUIP.
5. CIRCUITRY ESTIMATED @ .25 #/PICK-UP AND 25 PICK-UPS PER SYSTEM, BASED ON GEMINI DATA.
6. DETAIL VALVE WEIGHT ANAYSIS IS GIVEN ON PAGES 2.11-15 & -16. VALVE UNIT WEIGHTS ARE BASED ON COMPARABLE HARDWARE DATA.
7. DETAIL CIRCUITRY ANALYSIS IS GIVEN ON PAGE 2.11-17. WIRE ROUTING LENGTHS ARE ASSUMED THE SAME AS PLUMBING SINCE AVIONICS BAY IS LOCATED NEAR HYDRAULICS BAY. A 50% ROUTING FACTOR PLUS 50% CIRCUITRY INSTALLATION FACTOR IS USED BASED ON MDAC EXPERIENCE.
8. DETAIL PLUMBING REQUIREMENTS ARE DERIVED ON PAGES 2.11-18 & -20. VICKERS "HYDRAULIC TRANSMISSION LINE OPTIMIZATION STUDY" IS USED AS A BASIS FOR THIS ANALYSIS.

2.11 HYDRAULIC

LIST OF REFERENCES AND DATA SOURCES - CON'T

9. CRYOGENIC H_2 HEAT EXCHANGE WEIGHT IS BASED ON O-EAST-ECLS-1 COMPUTER PROGRAM FOR WEIGHT AND SIZING ANALYSIS.
10. VALVES, CONTROLS AND PLUMBING IS BASED ON CRYO H_2 H.X. SYSTEM GIVEN IN SECT. 2.14 ENVIRONMENTAL CONTROL.
11. SECONDARY ELEC. PUMP AND MOTOR UNIT WT. = 20 LB. BASED ON F-4 EMER. PACK PART NO. 32-69918.
12. CIRCUITRY AND MOUNTING STRUCTURE ARE BASED ON METHODS GIVEN IN SECT. 2.13. AND SPECIFICALLY:

LOCAL MTG. STRUCT. $= .412\,(407.02)^{.65} = 20.48$ LB/SYS.

EQ. BAY STRUCT $= 1.35\left(407.02 + \frac{925^{*} - 245}{4}\right)^{.65} = 84.16$ LB/SYS

* INCLUDES APU FROM PRIME POWER SECT. 2.9.

2.12 Surface Controls [4901]

		Page No.
Elevon Controls	[138]	2.12-7
Circuitry	(35)	2.12-12
Linkage	(103)	2.12-13
Elevon Power Xmission	[97]	2.12-7
Pressure Lines	(65)	2.11-18
Return Lines	(32)	2.11-18
Elevon Actuator	[2068]	2.12-7
Elevon Secondary Actuator	[52]	2.12-7
Elevon Supts Install	[227]	2.12-7
Actuator Supt	(220)	2.12-13
Secondary Act Mtg.	(7)	2.12-13
Rudder Controls	[57]	2.12-7
Circuitry	(18)	2.12-12
Linkage	(39)	2.12-13
Rudder Power Xmission	[48]	2.12-7
Pressure Lines	(34)	2.11-18
Return Lines	(14)	2.11-18
Rudder Actuator	[465]	2.12-7
Rudder Secondary Act.	[26]	2.12-7
Rudder Supts Install	[67]	2.12-7
Actuator Supt	(64)	2.12-13
Secondary Act. Mtg.	(3)	2.12-13
Speed Brake Controls	[72]	2.12-8
Circuitry	(8)	2.12-12
Linkage	(64)	2.12-13
Speed Brake Power Xmission	[8]	2.12-8
Pressure Lines	(5)	2.11-18
Return Lines	(3)	2.11-18
Speed Brake Actuator	[913]	2.12-8
Speed Brake Secondary Act.	[52]	2.12-8
Speed Brake Supts Install	[130]	2.12-8
Actuator Supt	(123)	2.12-13
Secondary Act. Mtg.	(7)	2.12-13
Contingency	[481]	2.12-5

2.12 Surface Controls

General - Aerodynamic control is accomplished by means of conventional control surfaces i.e., elevon, rudder, and speed brakes. Each elevon is powered by 3 tandem actuators and the speed brake and rudders are powered by 2 tandem actuators. This arrangement provides for the minimum installed power required to meet the failure criteria. Actuator design data is shown on Page 2.12-16.

The actuators will incorporate state of the art improvements such as dual seals, inlet check, rip stops, anti-cavitation valves, leak detection and dual load path feedback linkage. Switching valves will be incorporated into the elevon actuators to allow switching of a standby hydraulic power system into an actuator cylinder chamber which has experienced a loss of hydraulic power from the active system. The actuator main control spool will be positioned by a control servo which receives quad electronic control signals from the data bus, rather than by the conventional mechanical cable and push rod systems. This arrangement provides a redundant fly-by-wire control system. The only mechanical linkage in the primary control system is that which is necessary to synchronize the pilot and navigator sticks and rudder pedals and that between the control servo and the power actuators.

The control servo is a mechanization required to receive multiple electronic command signals and convert them to a single mechanical output. The control servo sums the input commands and detects for non-compliant commands. It also eliminates force fight at the power actuator and reduces transient effects of bad control signals. The conversion of electronic signals to a mechanical output is accomplished electrically utilizing a velocity summed system. The control servo is removed from the power actuator where multiple actuators are used i.e., elevons, rudders, speed brakes and is integrated with single actuators i.e., TVC, (Ref. Section 2.6). All control servos, i.e., secondary actuators, are common. (Reference MCAIR Procurement Specification No. PS 53-044004, Survivable Flight Control System Secondary Actuator, Spec. Wt. = 26 lbs.)

System operation is as follows: the pilot initiates a command via movement of the control stick or rudder pedals. These inputs are converted to electrical signals by force transducers. These signals are transmitted to the data bus. The data bus sums the input signals with the required control parameter and transmits the necessary control signals to the respective surface actuators which positions the control surface for the desired vehicle control. Quadrex feed back signals

from the actuator completes the servo control loop. Initiation of control command may be by either the pilot or automatic control via the data bus.

The aerodynamic surface actuators will be powered by each of the four hydraulic supply systems. The distribution of hydraulic power is such that any two hydraulic system worse condition failures, i.e., failure causing the loss of hydraulic fluid, results in no control system degradation. The surface actuators will be of the fixed body type with mechanical servo control, control valves, miscellaneous valves and feedback linkage. Reference Section 2.11 for Hydraulic system data.

Elevon Control System - The lateral and longitudinal control will be accomplished by means of an elevon control system. A single elevon on each wing will be powered by three servo controlled, dual tandem actuators. Each actuator is designed for 50 percent maximum hinge moment. Simultaneous movement of the elevon surfaces in the same direction will give the desired pitch control. Simultaneous differential of the elevons will provide the desired roll control. Lateral and longitudinal control will be accomplished by repositioning of the elevons by the data bus trim circuitry. Commands are initiated by pilot, copilot, or automatic control. Shutoff provisions for one half of each actuator is incorporated so that power requirements may be minimized during subsonic flight. Three systems are active and one standby.

Rudder Control System - Directional control of the vehicle shall be provided by a rudder control system. The rudder will be a single surface powered by two servo controlled, dual tandem actuators. Each actuator is designed for 100 percent hinge moment. Directional trim control is obtained by repositioning the surface actuator through the trim circuitry of the data bus.

Speed Brake Control System - The speed brakes will be utilized for both glide slope control and as energy dissipation devices. The proposed speed brake system utilizes two speed brake surfaces. There will be one surface each side of the fuselage with each surface being powered by two dual tandem hydraulic actuators. Each actuator is sized for 100 percent hinge moment.

A detail system description is given in MDAC Memo No. SSPI-E450-587.

METHODOLOGY - A hydraulic actuator analytical sizing model has been developed for accurate weight evaluation of the control surface actuators. This model has been automated so that parametric analyses can be performed. The complete program listing and basic nomenclature are given on pages 2.12-17 thru -19. The key elements of this sizing model are as follows:

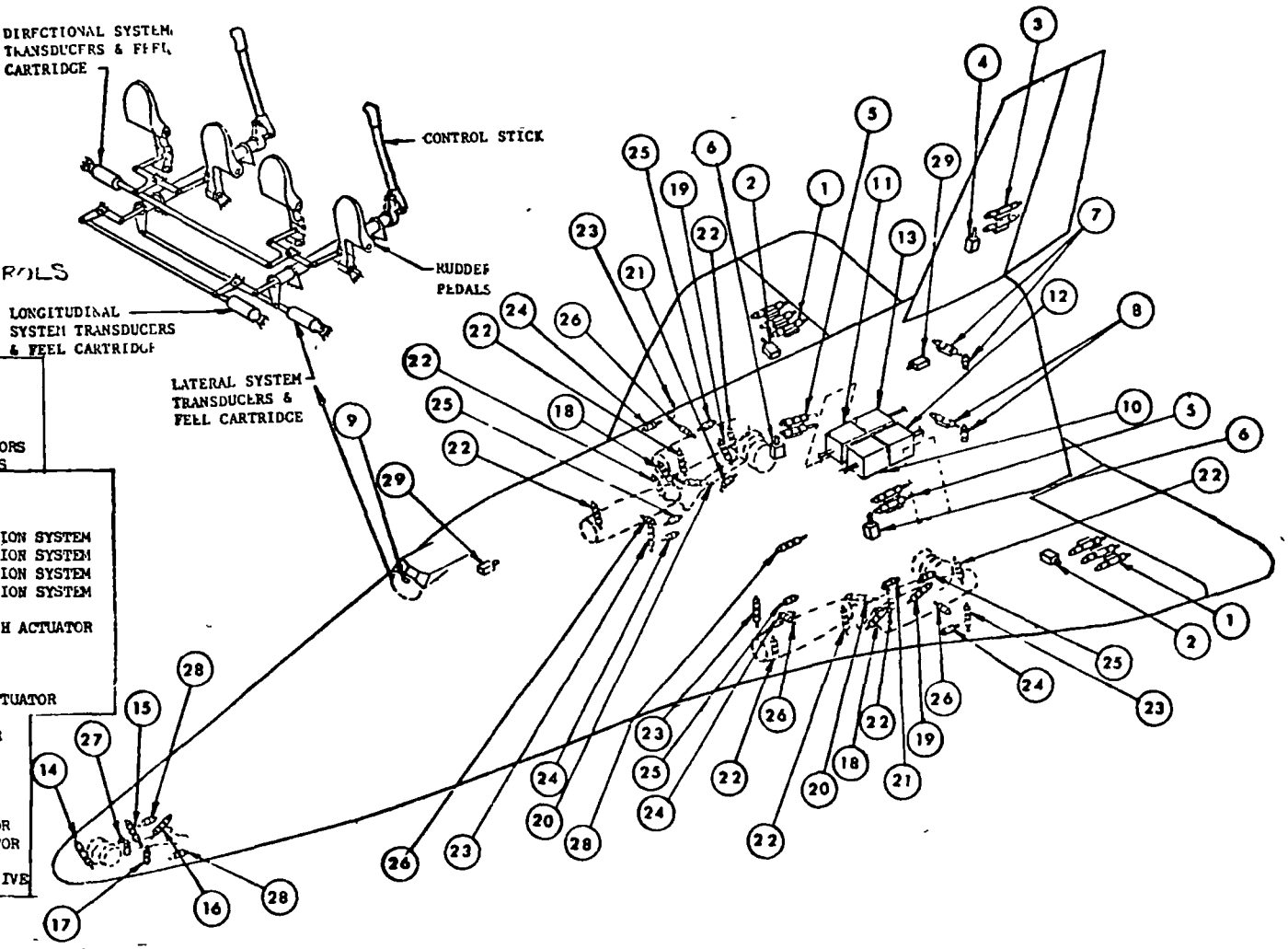
1. Actuator size, i.e., bore, stroke, wall thickness, etc., are analytically derived from basic loads data and then directly related to actuator weight.
   - ° Optimum rod D/t (designated K in the program) is solved for to satisfy external collapse pressure requirements.
   - ° Rod length and/or cylinder length is related to stroke which is directly related to moment arm and full deflection angle.
   - ° Then rod wall thickness is established either by column buckling or basic P/A requirements.
   - ° Required piston area is related to Hinge Moment, moment arm and operating pressure.
   - ° Actuator bore is then established knowing rod diameter and piston area.
   - ° Cylinder wall is sized for burst pressure requirements.
   - ° Cylinder ends and pistons are sized by flat plate pressure loading analysis.
2. The basic weight equations follow directly from solutions of dimensions discussed above and illustrated by the nomenclature shown on page 2.12-17.
3. A non-optimum factor which is related to axial load is derived by comparison with detail weight and design data for the DC-10 Inboard and Outboard aileron actuators. The basic design requirements for balanced dual tandem actuators is patterned after the DC-10 Aileron actuator design except that the Orbiter actuators will be end mounted in lieu of trunnion mounted. A slight modification to the actuator analysis program is made for this mounting arrangement and is illustrated on page 2.12-17
4. Actual vs. estimated data for the DC-10 trunnion mounted actuators is given on pages 2.12-20 & -21. Actual vs. estimated data for an end mounted actuator (National Water Lift Co. Dwg. No. L-3831002) is also given on page 2.12-22.

To further verify the validity of this analytical model, a similar program was developed for single actuators and resulting data compared well with data from Moog Tech Bulletin No. 119.

Weight equations for redundant valves and controls is based on DC-10 data but modified for the control system used for the Orbiter. Valve and control weight is related to flow (GPM) and is verified by DC-10 and Sanders Associates data.

Based on data shown in Section 1.0, 481 pounds is allowed for contingency.

HYDRAULIC EQUIPMENT LOCATION



SECT. 2 12 SURF CONTROLS

ITEM	COMPONENT
1	ELEVON SURFACE ACTUATORS
2	ELEVON SERVO ACTUATORS
3	RUDDER SURFACE ACTUATORS
4	RUDDER SERVO ACTUATOR
5	SPEED BRAKE SURFACE ACTUATORS
6	SPEED BRAKE SERVO ACTUATORS
7	UPPER ENGINE TVC ACTUATORS
8	LOWER ENGINE TVC ACTUATORS
9	HYDRAULIC CONTROL PANEL
10	#1 HYDRAULIC POWER GENERATION SYSTEM
11	#2 HYDRAULIC POWER GENERATION SYSTEM
12	#3 HYDRAULIC POWER GENERATION SYSTEM
13	#4 HYDRAULIC POWER GENERATION SYSTEM
14	N. G. DOOR ACTUATOR
15	N. G. DOOR AND GEAR UPLATCH ACTUATOR
16	N. G. ACTUATOR
17	N. G. DOOR LATCH ACTUATOR
18	M.L.G. DOOR ACTUATOR
19	M.L.G. DOOR AND UPLATCH ACTUATOR
20	M.L.G. ACTUATOR
21	M.L.G. DOOR LATCH ACTUATOR
22	ENGINE DOOR ACTUATOR
23	ENGINE ACTUATOR
24	ENGINE DOWN LOCK ACTUATOR
25	ENGINE UP LOCK ACTUATOR
26	ENGINE DOOR UPLOCK ACTUATOR
27	NOSE WHEEL STEERING ACTUATOR
28	APFS DOOR ACTUATOR
29	CARGO DOOR AND RADIATOR DRIVE

SECT 2 : HYDRAULIC

GROUP WEIGHT STATEMENT

4901

2.12. SURFACE CONTROLS						
COCKPIT CONTROLS						(SEE AVIONICS)
FLIGHT CONTROL SY		POWER		SEC-		(SEE AVIONICS)
SYSTEM ACTUATION	CONTROLS	XMISSION	ACTUATOR	ONDARY ACT.	SUPTS INSTALL.	
	(267)	(153)	(3446)	(130)	(424)	4420
AILERON	N/A	N/A	N/A	N/A	N/A	
ELEVON	138	97	2068	52	227	
RUDDER	57	48	466	26	67	
T.E. FLAP	N/A	N/A	N/A	N/A	N/A	
SPEED BRAKE	72	8	913	52	130	
CONTINGENCY						481

WEIGHT SUBSTANTIATION

ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT	PAGE NO.
ELEVON CONTROLS			(138.37)	
CIRCUITRY			35.57	2.12-12
LINKAGE			102.80	2.12-13
ELEVON POWER XMISSION			(97.53)	
PRESSURE LINES			65.08	2.11-18
RETURN LINES			32.45	2.11-18
ELEVON ACTUATOR	344.61	6	(2067.66)	2.12-9
ELEVON SECONDARY ACT.	26.0	2	(52.0)	2.12-2
ELEVON SUPTS INSTALL			(227.32)	
ACTUATOR SUPT.	36.75	6	220.48	2.12-13
SECONDARY ACT. MTG.	3.42	2	6.84	2.12-13
RUDDER CONTROLS			(56.87)	
CIRCUITRY			17.47	2.12-12
LINKAGE			39.40	2.12-13
RUDDER POWER XMISSION			(47.73)	
PRESSURE LINES			34.18	2.11-18
RETURN LINES			13.55	2.11-18
RUDDER ACTUATOR	232.49	2	(464.98)	2.12-10
RUDDER SECONDARY ACT.	26.0	1	(26.0)	2.12-2
RUDDER SUPTS INSTALL.			(67.35)	
ACTUATOR SUPT.	31.96	2	63.93	2.12-13
SECONDARY ACT. MTG.	3.42	1	3.42	2.12-13

WEIGHT SUBSTANTIATION

2.12 SURFACE CONTROLS ~ CON'T.

ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT	PAGE NO.
SPEED BRAKE CONTROLS			(71.71)	
CIRCUITRY			8.11	2.12-12
LINKAGE			63.60	2.12-13
SPEED BRAKE POWER XMISSION			(7.71)	
PRESSURE LINES			4.41	2.11-18
RETURN LINES			3.30	2.11-18
SPEED BRAKE ACTUATOR	228.26	4	(913.04)	2.12-11
SPEED BRAKE SECONDARY ACT.	26.0	2	(52.0)	2.12-2
SPEED BRAKE SUPTS INSTALL.			(129.48)	
ACTUATOR SUPT.	30.66	4	122.64	2.12-13
SECONDARY ACT MTG.	3.42	2	6.84	2.12-13
SUBTOTAL SURFACE CONTROLS			4419.75	
CONTINGENCY ~ 11%			481	
TOTAL SURFACE CONTROLS			4900.75	

WEIGHT SUBSTANTIATION

END MNTED ACTUATOR ANALYSIS

ELEVON-6 REQUIRED

HINGE MOMENT =	3060000. IN-LB	SURFACE TRAVEL =	65.00 DEG
MOMENT ARM =	13.50 IN	SURFACE RATE =	35.00 DEG/SEC
STROKE =	14.51 IN	FACTOR OF SAFETY =	1.50
FLOW RATE =	76.65 GPM	HORSEPOWER =	134.14 HP
OPERATING PRESS =	3000. PSI	BURST PRESSURE =	7500. PSI

DESIGN AXIAL LOAD =	226667. LB
OPERATING AXIAL LOAD =	113333. LB
ULTIMATE AXIAL LOAD =	340000. LB

MATERIAL - STEEL DENSITY = .283 PCI E = 30000000. PSI
FTU = 260000. PSI FCY = 240000. PSI

CYLINDER LENGTH =	65.28 IN	CYLINDER DIAM =	7.89 IN
CYL WALL THICK =	.114 IN	ROD DIAMETER =	3.76 IN
ROD WALL THICK =	.181 IN	END THICKNESS =	.822 IN
PISTON AREA =	37.78 SQ.IN.	PISTON THICK =	.993 IN
SWEPT VOLUME =	548.04 CU.IN.	NON-OPT FACTOR =	1.2457
ROD D/T =	20.75		

ROD WEIGHT =	101.89 LB.
PISTON WEIGHT =	21.23 LB.
CYLINDER WEIGHT =	79.22 LB.
NON-OPTIMUM =	49.71 LB.
BASIC ACTUATOR WT =	252.05 LB.
END MNTG WEIGHT =	16.19 LB.
VALVES & CONTROL WT =	76.37 LB.
SECONDARY WEIGHT =	.00 LB.
TOTAL ACTUATOR WT =	344.61 LB.
FLUID WEIGHT =	32.88 LB. (SEE PAGE 2.11-12)
TOTAL WET WEIGHT =	377.49 LB.

WEIGHT SUBSTANTIATION

END MNTED ACTUATOR ANALYSIS

RUDDER-2 REQUIRED

HINGE MOMENT =	1300000. IN-LB	SURFACE TRAVEL =	60.00 DEG
MOMENT ARM =	7.00 IN	SURFACE RATE =	30.00 DEG/SEC
STROKE =	7.00 IN	FACTOR OF SAFETY =	1.50
FLOW RATE =	28.14 GPM	HORSEPOWER =	49.24 HP
OPERATING PRESS =	3000. PSI	BURST PRESSURE =	7500. PSI

DESIGN AXIAL LOAD =	185714. LB
OPERATING AXIAL LOAD =	92857. LB
ULTIMATE AXIAL LOAD =	278571. LB

MATERIAL - STEEL DENSITY = .283 PCI E = 30000000. PSI
FTU = 260000. PSI FCY = 240000. PSI

CYLINDER LENGTH =	31.50 IN	CYLINDER DIAM =	7.17 IN
CYL WALL THICK =	.103 IN	ROD DIAMETER =	3.46 IN
ROD WALL THICK =	.167 IN	END THICKNESS =	.743 IN
PISTON AREA =	30.95 SQ.IN.	PISTON THICK =	.894 IN
SWEPT VOLUME =	216.67 CU.IN.	NON-OPT FACTOR =	1.3234
ROD D/T =	20.75		

ROD WEIGHT =	65.59 LB.
PISTON WEIGHT =	15.66 LB.
CYLINDER WEIGHT =	40.58 LB.
NON-OPTIMUM =	39.40 LB.
BASIC ACTUATOR WT =	161.23 LB.
END MNTG WEIGHT =	13.57 LB.
VALVES & CONTROL WT =	57.69 LB.
SECONDARY WEIGHT =	.00 LB.
TOTAL ACTUATOR WT =	232.49 LB.
FLUID WEIGHT =	13.00 LB. (SEE PAGE 2.11-12)
TOTAL WET WEIGHT =	245.49 LB.

WEIGHT SUBSTANTIANTION

END MNTED ACTUATOR ANALYSIS

SPEED BRAKE-4 REQUIRED

HINGE MOMENT =	1400000. IN-LB	SURFACE TRAVEL =	60.00 DEG
MOMENT ARM =	8.00 IN	SURFACE RATE =	25.00 DEG/SEC
STROKE =	8.00 IN	FACTOR OF SAFETY =	1.50
FLOW RATE =	25.25 GPM	HORSEPOWER =	44.19 HP
OPERATING PRESS =	3000. PSI	BURST PRESSURE =	7500. PSI

DESIGN AXIAL LOAD =	175000. LB
OPERATING AXIAL LOAD =	87500. LB
ULTIMATE AXIAL LOAD =	262500. LB

MATERIAL - STEEL DENSITY = .283 PCI E = 30000000. PSI
FTU = 260000. PSI FCY = 240000. PSI

CYLINDER LENGTH =	36.00 IN	CYLINDER DIAM =	6.97 IN
CYL WALL THICK =	.100 IN	ROD DIAMETER =	3.38 IN
ROD WALL THICK =	.163 IN	END THICKNESS =	.721 IN
PISTON AREA =	29.17 SQ.IN.	PISTON THICK =	.866 IN
SWEPT VOLUME =	233.33 CU.IN.	NON-OPT FACTOR =	1.3474
ROD D/T =	20.75		

ROD WEIGHT =	63.42 LB.
PISTON WEIGHT =	14.30 LB.
CYLINDER WEIGHT =	40.58 LB.
NON-OPTIMUM =	41.11 LB.
BASIC ACTUATOR WT =	159.42 LB.
END MNTG WEIGHT =	12.88 LB.
VALVES & CONTROL WT =	55.96 LB.
SECONDARY WEIGHT =	.00 LB.
TOTAL ACTUATOR WT =	228.26 LB.
FLUID WEIGHT =	14.00 LB. (SEE PAGE 2.11-12)
TOTAL WET WEIGHT =	242.26 LB.

WEIGHT SUBSTANTIATION

HYDRAULIC SYSTEM

FLIGHT CONTROL SYSTEM CIRCUITRY

USE PLUMBING ROUTING LENGTHS AS ESTIMATE FOR CIRCUITRY ROUTING (REF. PAGE 2.11-21). AVIONICS BAY IS LOCATED NEAR HYDRAULICS BAY.

SECONDARY ACTUATORS

CIRCUIT UNIT WT. = 4 LB/1000 FT × 13 SIGNALS × 4 PICK-UPS/ACT,
= .208 LB/FT/ACT × 1.50 FOR CLAMPS & INSTL.
= .312 LB/FT

ELEVONS (2) SECONDARY ACTUATORS
WT. = (13 FT + 44 FT) × 2 REQ'D × .312 LB/FT = 35.57

RUDDER (1) SECONDAY ACTUATOR
WT. = 56 FT × .312 LB/FT = 17.47

SPEED BRAKE (2) SECONDARY ACTUATORS
WT. = 13 FT × 2 REQ'D. × .312 LB/FT = 8.11

SUBTOTAL SURFACE CONTROLS (61.15 LB)

WEIGHT SUBSTANTIATION

2.12 SURFACE CONTROLS

MECHANICAL LINKAGE (REDUNDANT)
FOR ACTUATOR / SECONDARY CONNECTION
FROM PG. 2.12-14 ; "x" MEASURED, "Y" MEASURED - $\frac{2.5 \times \text{STROKE}}{12 \text{ IN/FT}}$

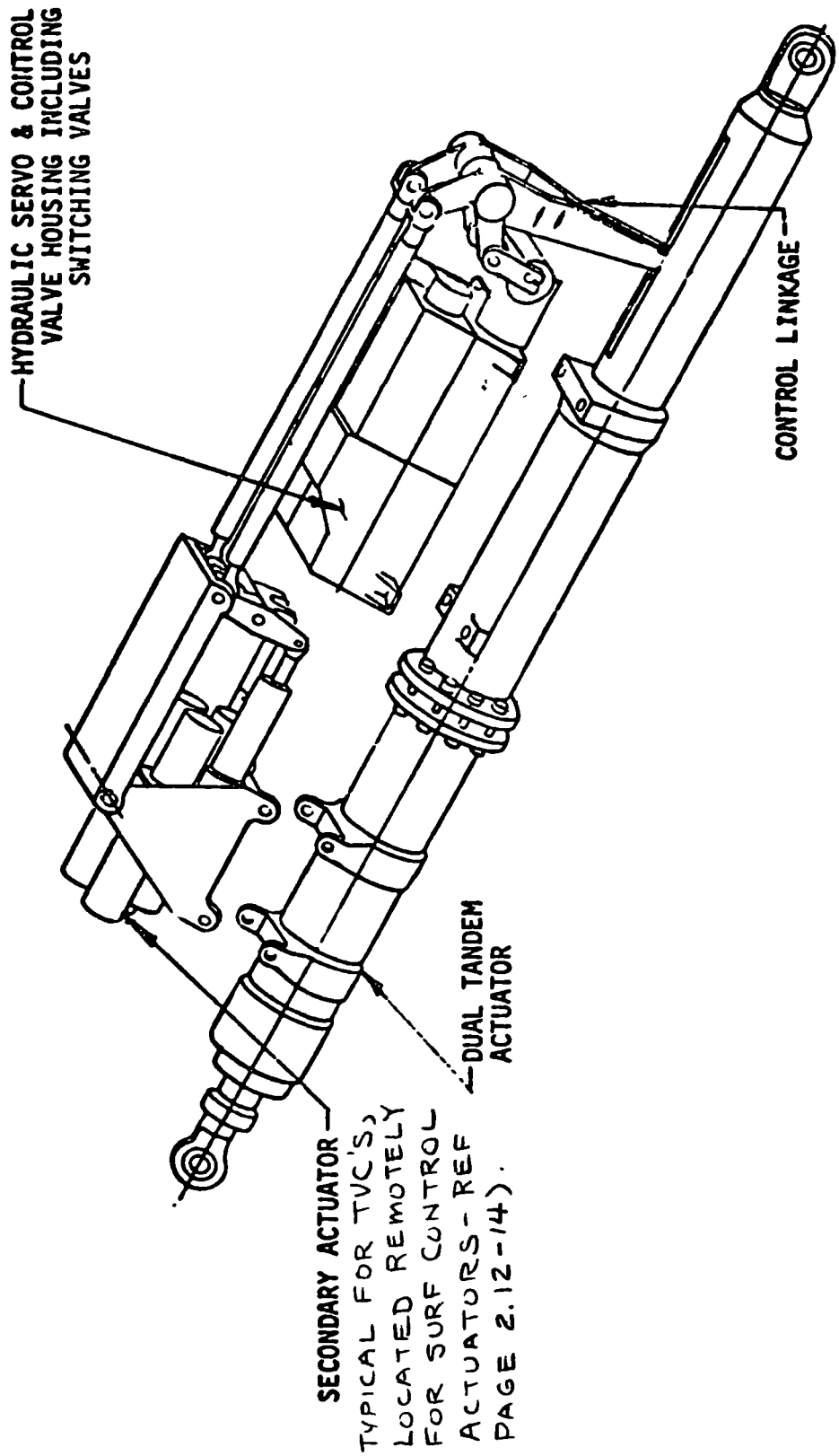
ACTUATOR	"Y" FT. ①	QTY/SEC. ACT. ②	"X" FT. ③	TOTAL ℓ FT. ①×②+③ = ④	QTY. SEC. ACT.	TOTAL WT. ④×2 LB/FT
ELEVON	3.0	3	16.7	25.7	2	102.8
RUDDER	1.5	2	16.7	19.7	1	39.4
SPEED BRAKE	1.7	2	12.5	15.9	2	63.6
				TOTAL MECH. LINKAGE		(205.8)

ACTUATOR STRUCTURAL PROVISIONS
$WT/ACT = \frac{1.065}{2}(LOAD/ACT \times 10^{-3})^{.7}$ REF. MCAIR REPORT NO. 747 VOL I PG. 3.1.4

ITEM	WT/ACT	QTY	TOTAL WT.
ELEVON	$.825(226.667)^{.7} = 36.75$	6	220.48
RUDDER	$.825(185.714)^{.7} = 31.96$	2	63.93
SP. BRAKE	$.825(175.)^{.7} = 30.66$	4	122.64
SECONDARY	ACT. MNTG. $= .412(26)^{.63} = 3.42$	5	17.12
			TOTAL STRUCTURAL PROVISIONS (424.17)

WEIGHT SUBSTANTIATION
ELEVON ACTUATOR
MECHANICAL LINKAGE – TYPICAL

ASSUME 1 INCH O.D. STEEL TUBING X .083" WALL = .068 #/IN = .83 #/FT
ADD .17 #/FT FOR LINKS AND FITTINGS ∴ UNIT WT. = 1 #/FT. X 2 REQ'D FOR
REDUNDANT LINKAGE = 2 #/FT TOTAL UNIT WT. USE DISTANCE "X" + "Y" (NO ACTS)



TYPICAL INTEGRATED CONTROL SURFACE ACTUATOR

WEIGHT _____ STANTIATION

HIGH CROSS RANGE ORBITER CONTROL SURFACE ACTUATOR DESIGN DATA									
ITEM	SURFACE ACT.	ACT. H M (STALL) (IN-LBS)	SURF TRAVEL (DEGREES)	SURF. RATE (DEG/SEC)	MOMENT ARM (INCHES)	ACT STROKE (INCHES)	LOAD/ACT CHAMBER (LBS)	ACT BORE (INCHES)	WEIGHT (DRY)
1	Elevon	3.06×10^6	65 (+50 -15)	35	13.5	14.5	113,333	7.89	344
2	Rudder	1.3×10^6	60 (+30 -30)	30	7.0	7.0	92,857	7.17	232
3	Speed Brake	1.4×10^6	60 (+60 -0)	25	8.0	8.0	87,500	6.97	228
4*	TVC (Pitch)	2.5×10^6	11.6 ($\pm$5.8)	10	30.13	1.76	87,700	6.75	141
5*	TVC (Yaw)	2.5×10^6	5.8 ($\pm$2.9)	10	30.13	1.76	87,700	6.75	141

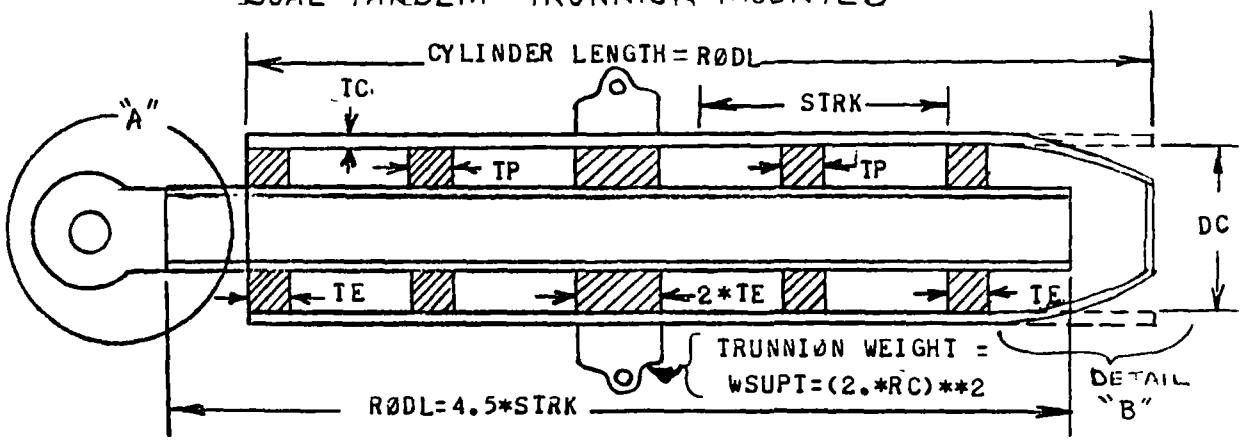
*Based on Rocketdyne Engine Requirements. ALSO, REFERENCE WT ONLY INCLD'D IN SECT 2.6.

PROPULSION - ASCENT

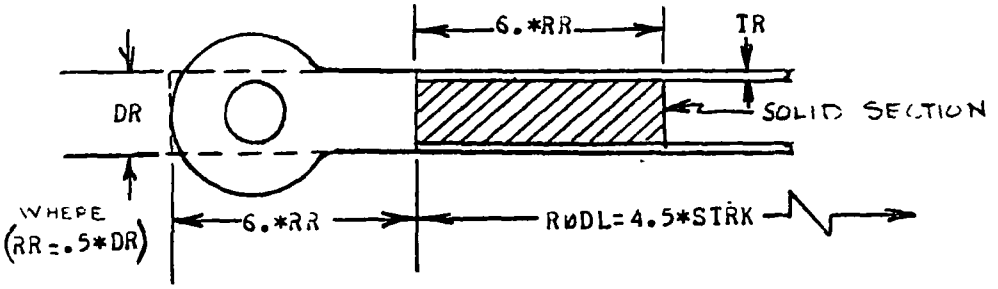
```
 EDIT ACDATA _H/D[illegible] ACTUATOR ANALYSIS INPUT DATA FILE
*TY0-20
    1.000   ELEVON-6 REQUIRED
    2.000   STEEL
    3.000   FS=1.5,E=30.E06,FCY=240000.,FTU=260000.,POP=3000.
    4.000   PBUR=7500.,RATE=35.,RHO=.283,WSEC=0.,GPMIN=0.
    5.000   ARM=13.5,DEFL=65.,HM=3.06E06,AXOP=0.,STROKE=0.*
    6.000   RUDDER-2 REQUIRED
    7.000   STEEL
    8.000   HM=1.3E06,DEFL=60.,RATE=30.,ARM=7.*
    9.000   SPEED BRAKE-4 REQUIRED
   10.000   STEEL
   11.000   HM=1.4E06,DEFL=60.,RATE=25.,ARM=8.*
```

HYDRAULIC ACTUATOR ANALYSIS
NOMENCLATURE

DUAL TANDEM - TRUNNION MOUNTED

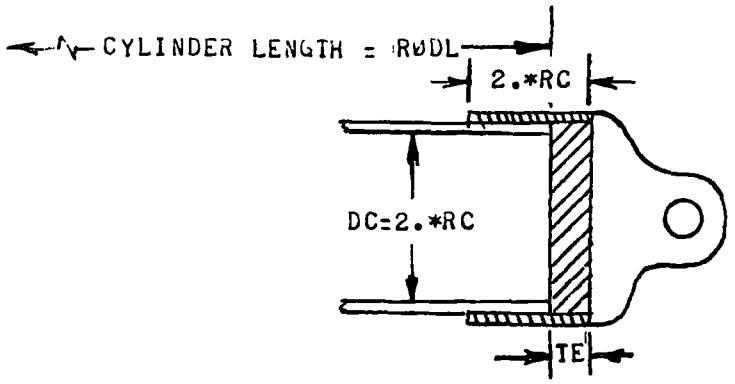


DETAIL "A"



DETAIL "B"

FOR END MOUNTED ACTUATORS
DELETE TRUNNION & ADD:



END MNTG WEIGHT =
WSUPT=WPT*RHØ*((TE*RC**2+((RC+TC)**2-RC**2)*2.*RC)+3.*RC*TE) (REFERENCE LINE 48 ON PAGE 2.12-)
ALSO, CHANGE CENTER DAM FROM 2*TE TO 1*TE. (SEE LINE 45, PAGE 2.12-)

HYDRAULIC ACTUATOR ANALYSIS COMPUTER PROGRAM LISTING

```
TY0-50.2
  1.000 C       THIS PROGRAM COMPUTES ACTUATOR WEIGHT KNOWING
  2.000 C      GEOMETRY AND LOADING
  3.000        INTEGER FID(3),MATL(3),TITLE(7)
  3.100        REAL PI/3.14159265/,K
  4.000        NAMELIST
  5.000       & ARM,DEFL,HM,AXOP,STROKE,FS,E,FCY,FTU
  6.000       &,POP,PBUR,RATE,RHO,WSEC,GPMIN
  7.000        WRITE(108,899)
  8.000        READ(105,900) FID
  8.100        WRITE(108,908)
  8.200        READ(105,909)ITYP
  8.300        IF(ITYP.EQ.2)WRITE(108,907)
  9.000        CALL OPENF1(FID)
 10.000        CALL EOFSET(998S)
 10.500    1   READ(1,898)TITLE
 11.000        READ(1,900)MATL
 12.000        INPUT(1)
 13.000        STRK=2.*ARM*SIN(.5*DEFL/57.2958)
 14.000        IF(STROKE.GT.0) STRK=STROKE
 15.000        ALDES=HM/ARM
 16.000        ALOP=.5*ALDES
 17.000        IF(AXOP.GT.0.) ALOP=AXOP
 18.000        ALULT=FS*2.*ALOP
 19.000        RODL=4.5*STRK
 19.500        K=2/((3.5556*PBUR/E)**.333)
 20.000        TR=((ALULT*RODL**2)/((K-1.)*(.5*K-.5)**2*E*PI**3))**.25
 21.000        TR1=SQRT(ALULT/((K-1.)*PI*FCY))+.03
 22.000        IF(TR1.GT.TR) TR=TR1
 23.000  701   DR=K*TR
 24.000        RR=.5*DR
 25.000  700   APIST=ALOP/POP
 26.000        RC=SQRT((APIST+PI*RR**2)/PI)
 27.000        DC=2.*RC
 28.000        TC=PBUR*RC/FTU
 29.000        TE=((.225*PBUR*(11.*RC**4+2.33*RR**4-RC**2*RR**2
 30.000       & *(13.33+17.33*ALOG(RC/RR))))/(FTU*(RC**2-RR**2)))
 31.000       &  **.5
 32.000        TP=((.225*PBUR*(RC**4*(17.333*ALOG(RC/RR)-6.33)
 33.000       &+RR**2*(4.*RC**2+2.333*RR**2)))/(FTU*(RC**2-RR**2)))
 34.000       &  **.5
 35.000        VOL=APIST*STRK
 36.000        FLOW=VOL*RATE/DEFL
 37.000        GPM=FLOW*60./231.
 38.000        IF(GPMIN.GT.0.) GPM=GPMIN
 39.000        HP=GPM*POP/1714.29
 40.000        OPT=59.4885/ALULT**.30354
 41.000        IF(OPT.LT.1.) OPT=1.
 42.000        WROD=PI*RHO*((K-1.)*RODL*TR**2+6.*(RR-TR)**2
 43.000       & *RR+6.*RR**3)
 44.000        WPIST=PI*RHO*2.*(RC**2-RR**2)*TP
 45.000        WCYL=PI*RHO*(RODL*TC*(2.*RC+TC)+4.*(RC**2-RR**2)*TE)
 46.000        CONI=(OPT-1.)*(WROD+WPIST+WCYL)
 47.000        WACT=OPT*(WROD+WPIST+WCYL)
 48.000        WSUPT=(2.*RC)**2
 49.000        WVALV=18.58*GPM**1.27
 49.200        IF(GPM.GE.1..AND.GPM.LT.2.)WVALV=18.58*GPM**.57
 49.600        IF(GPM.GE.2.)  WVALV=22.66*GPM**.28
 50.000        WEIGHT=WACT+WSUPT+WVALV+WSEC
 50.100        FLUID=VOL*.03*2.
 50.200        WETWT=WEIGHT+FLUID
*
```

HYDRAULIC ACTUATOR ANALYSIS
COMPUTER PROGRAM LISTING – CON'T

```
TY50.5-91
 50.500        IF(ITYP.EQ.1)GO TO 800
 50.600        IF(ITYP.EQ.2)GO TO 801
 51.000        WRITE(108,901)TITLE,HM,DEFL,ARM,RATE,STRK,FS,GPM,HP,POP
 51.100       &,PBUR
 52.000        WRITE(108,902)ALDES,ALOP,ALULT
 53.000        WRITE(108,903)MATL,RHO,E,FTU,FCY
 54.000        WRITE(108,904)RODL,DC,TC,DR,TR,TE,APIST,TP,VOL,OPT,K
 55.000        WRITE(108,905)WROD,WPIST,WCYL,CONT,WACT,WSUPT,WVALV
 56.000       &,WSEC,WEIGHT,FLUID,WETWT
 57.000        GO TO 1
 57.100  800   WRITE(108,906)TITLE,HP,WEIGHT,WETWT
 57.110        GO TO 1
 57.150  801   WRITE(108,910)ALOP,STRK,GPM,HP,WACT,WSUPT,WVALV,WEIGHT
 57.160       &,WETWT
 57.200        GO TO 1
 58.000  998   GO TO 999
 59.000  999   CALL CLOSFI
 60.000        STOP
 60.500  898   FORMAT(7A4)
 61.000  899   FORMAT(' WHAT FILE CONTAINS THE DATA?..PLEASE')
 62.000  900   FORMAT(3A4)
 63.000  901   FORMAT('1',22X,'HYDRAULIC ACTUATOR ANALYSIS'//'22X,7A4
 64.000       &//5X,'HINGE MOMENT = ',F10.0,' IN-LB ',5X,'SURFACE
 65.000       &' TRAVEL = ',F8.2,' DEG /5X,'MOMENT ARM = ',F12.2,' IN ',8X
 66.000       &,'SURFACE RATE = ',F10.2,' DEG/SEC '/5X,'STROKE = ',F16.2
 67.000       &,' IN ',8X,'FACTOR OF SAFETY = ',F6.2/5X,'FLOW RATE = 'F
 68.000       &13.2,' GPM ',7X,'HORSEPOWER = ',F12.2,' HP '/5X,'OPERATING'
 69.000       &' PRESS = ',F7.0,' PSI '7X,'BURST PRESSURE = ',F8.0,
 70.000       &' PSI '/)
 71.000  902   FORMAT(17X,'DESIGN AXIAL LOAD = ',F13.0,' LB'
 72.000       &/17X,'OPERATING AXIAL LOAD = ',F10.0,' LB'
 73.000       &/17X,'ULTIMATE AXIAL LOAD = ',F11.0,' LB'/)
 74.000  903   FORMAT(5X,'MATERIAL - ',3A4,2X,'DENSITY = ',F6.3,' PCI'
 75.000       &,2X,'E = 'F10.0,' PSI '/5X,'FTU = 'F10.0,
 76.000       &' PSI ',6X,'FCY = ',F10.0,' PSI '/)
 77.000  904   FORMAT(5X,'CYLINDER LENGTH = ',F7.2,' IN ',9X,'CYLINDER'
 78.000       &' DIAM = ',F9.2,' IN '/5X,'CYL WALL THICK =
 79.000       &,F8.3,' IN ',9X,'ROD DIAMETER = ',F10.2,' IN '/5X
 80.000       &,'ROD WALL THICK = ',F8.3,' IN ',9X,'END THICKNESS = F9.3
 81.000       &,' IN '/5X,'PISTON AREA = ',F11.2,' SQ.IN. ',5X
 82.000       &,'PISTON THICK = ',F10.3,' IN '/5X,'SWEPT VOLUME =
 83.000       &,F10.2,' CU.IN. ',5X,'NON-OPT FACTOR = ',F9.4/5X,'ROD D/T'
 83.500       &' = ',F15.2/)
 84.000  905   FORMAT(20X,'ROD WEIGHT = ',F19.2,' LB. '/20X
 85.000       &'PISTON WEIGHT = 'F16.2,' LB. '/20X,'CYLINDER WEIGHT ='
 86.000       &,F14.2,' LB. '/20X,'NON-OPTIMUM = ',F18.2,' LB. '/20X,
 87.000       &'BASIC ACTUATOR WT = ',F12.2,' LB. '//20X,'TRUNNION
 88.000       &' WEIGHT = ',F14.2,' LB. '//20X,'VALVES & CONTROL WT ='
 89.000       &F10.2,' LB. '//20X,'SECONDARY WEIGHT = ',F13.2,' LB.
 90.000       &//20X,'TOTAL ACTUATOR WT = ',F12.2,' LB.
 90.100       &//20X,'FLUID WEIGHT = ',F17.2,' LB.
 90.200       &//20X,'TOTAL WET WEIGHT = ',F13.2,' LB.')
 90.400  906   FORMAT(7A4,3F14.2)
 90.500  907   FORMAT('1',2X,'A.L.',3X,'STROKE',3X,'GPM',7X,'HP',4X,
 90.510       &'WACT',4X,'WSUPT',3X,'WVALV',2X,'W(DRY)',2X,'W(WET)'//)
 90.520  910   FORMAT(F8.0,8F8.2)
 90.530  909   FORMAT(I1)
 90.540  908   FORMAT('ITYP EQUALS ?')
 91.000        END
*
```

HYDRAULIC ACTUATOR ANALYSIS

TRUNNION MOUNTED

DC TEN INBD AILERON

HINGE MOMENT =	0. IN-LB	SURFACE TRAVEL =	.00 DEG
MOMENT ARM =	.00 IN	SURFACE RATE =	.00 DEG/SEC
STROKE =	4.83 IN	FACTOR OF SAFETY =	1.50
FLOW RATE =	9.88 GPM	HORSEPOWER =	17.29 HP
OPERATING PRESS =	3000. PSI	BURST PRESSURE =	7500. PSI

DESIGN AXIAL LOAD =	0. LB
OPERATING AXIAL LOAD =	23640. LB
ULTIMATE AXIAL LOAD =	70920. LB

MATERIAL - STEEL DENSITY = .283 PCI E = 30000000. PSI
FTU = 260000. PSI FCY = 240000. PSI

CYLINDER LENGTH =	21.75 IN	CYLINDER DIAM =	3.78 IN	3.744
CYL WALL THICK =	.054 IN	ROD DIAMETER =	2.05 IN	1.977
ROD WALL THICK =	.099 IN	END THICKNESS =	.369 IN	
PISTON AREA =	7.88 SQ.IN.	PISTON THICK =	.429 IN	
SWEPT VOLUME =	38.09 CU.IN.	NON-OPT FACTOR =	2.0046	
ROD D/T =	20.75			

		ACT/EST	
ROD WEIGHT =	14.25 LB.		
PISTON WEIGHT =	1.91 LB.		
CYLINDER WEIGHT =	7.32 LB.		
NON-OPTIMUM =	23.59 LB.		
BASIC ACTUATOR WT =	47.08 LB.	47.81	1.016
TRUNNION WEIGHT =	14.25 LB.	14.50	1.018
VALVES & CONTROL WT =	43.03 LB.	43.00	.999
SECONDARY WEIGHT =	.00 LB.		
TOTAL ACTUATOR WT =	104.37 LB.	105.31	1.009
FLUID WEIGHT =	2.29 LB.		
TOTAL WET WEIGHT =	106.65 LB.		

☐ ACTUAL DATA

HYDRAULIC ACTUATOR ANALYSIS
TRUNNION MOUNTED
DC TEN OUTBD AILERON

HINGE MOMENT =	0. IN-LB	SURFACE TRAVEL =	.00 DEG
MOMENT ARM =	.00 IN	SURFACE RATE =	.00 DEG/SEC
STROKE =	3.76 IN	FACTOR OF SAFETY =	1.50
FLOW RATE =	2.13 GPM	HORSEPOWER =	3.73 HP
OPERATING PRESS =	3000. PSI	BURST PRESSURE =	10100. PSI

DESIGN AXIAL LOAD =	0. LB
OPERATING AXIAL LOAD =	6540. LB
ULTIMATE AXIAL LOAD =	19620. LB

MATERIAL - STEEL DENSITY = .283 PCI E = 30000000. PSI
FTU = 260000. PSI FCY = 240000. PSI

CYLINDER LENGTH =	16.92 IN	CYLINDER DIAM =	2.10 IN	2.118
CYL WALL THICK =	.041 IN	ROD DIAMETER =	1.28 IN	1.31
ROD WALL THICK =	.068 IN	END THICKNESS =	.221 IN	
PISTON AREA =	2.18 SQ.IN.	PISTON THICK =	.250 IN	
SWEPT VOLUME =	8.20 CU.IN.	NON-OPT FACTOR =	2.9609	
ROD D/T =	18.79			

		ACT/EST	
ROD WEIGHT =	3.78 LB.		
PISTON WEIGHT =	.31 LB.		
CYLINDER WEIGHT =	1.86 LB.		
NON-OPTIMUM =	11.66 LB.		
BASIC ACTUATOR WT =	17.61 LB.	17.65	1.002
TRUNNION WEIGHT =	4.42 LB.	4.16	.941
VALVES & CONTROL WT =	28.00 LB.	28.20	1.007
SECONDARY WEIGHT =	.00 LB.		
TOTAL ACTUATOR WT =	50.03 LB.	50.01	1.000
FLUID WEIGHT =	.49 LB.		
TOTAL WET WEIGHT =	50.52 LB.		

☐ ACTUAL DATA

END MNTED ACTUATOR ANALYSIS
DIFFERENTIAL STABILATOR ACTUATOR
NATIONAL WATER LIFT CO. DWG. NO. L-3831002

HINGE MOMENT =	0. IN-LB	SURFACE TRAVEL =	.00 DEG
MOMENT ARM =	.00 IN	SURFACE RATE =	.00 DEG/SEC
STROKE =	9.19 IN	FACTOR OF SAFETY =	1.50
FLOW RATE =	9.88 GPM	HORSEPOWER =	17.29 HP
OPERATING PRESS =	3000. PSI	BURST PRESSURE =	7500. PSI

DESIGN AXIAL LOAD =	0. LB
OPERATING AXIAL LOAD =	20580. LB
ULTIMATE AXIAL LOAD =	61740. LB

MATERIAL - STEEL DENSITY = .283 PCI E = 30000000. PSI
FTU = 260000. PSI FCY = 240000. PSI

CYLINDER LENGTH =	41.35 IN	CYLINDER DIAM =	3.55 IN 3.50
CYL WALL THICK =	.051 IN	ROD DIAMETER =	1.96 IN 1.875
ROD WALL THICK =	.094 IN	END THICKNESS =	.343 IN
PISTON AREA =	6.86 SQ.IN.	PISTON THICK =	.398 IN
SWEPT VOLUME =	63.04 CU.IN.	NON-OPT FACTOR =	2.0908
ROD D/T =	20.75		

			ACT/EST
ROD WEIGHT =	15.57 LB.		
PISTON WEIGHT =	1.55 LB.		
CYLINDER WEIGHT =	8.76 LB.		
NON-OPTIMUM =	28.23 LB.		
BASIC ACTUATOR WT =	54.11 LB.	54.54	1.008
END MNTG WEIGHT =	3.90 LB.	3.85	.987
VALVES & CONTROL WT =	43.03 LB.	N/A	N/A
SECONDARY WEIGHT =	.00 LB.		
TOTAL ACTUATOR WT =	101.04 LB.	N/A	N/A
FLUID WEIGHT =	3.78 LB.		
TOTAL WET WEIGHT =	104.82 LB.		

☐ ACTUAL DATA

2.13. Avionics	4588 lb	Page No.
Guidance and Navigation	[516]	2.13-8
Inertial Measurement Unit	(140)	
Star Tracker	(120)	
Horizon Sensor	(32)	
Circuitry	(62)	
Navigation Base	(80)	
Local Mounting Structure	(19)	
Equipment Bay Structure	(63)	
Flight Control System	[327]	2.13-11
Thruster Electronics	(68)	
Actuator Electronics	(114)	
Rate Gyro Package	(16)	
Total Temp & Press Sensor	(10)	
Accelerometer	(6)	
Static Press Sensor	(10)	
Circuitry	(44)	
Local Mounting Structure	(14)	
Equipment Bay Structure	(45)	
Data Management	[1202]	2.13-11
Central Computer	(340)	
System Control Unit	(7)	
Mass Memory	(32)	
Area DIU's	(139)	
Crew Station DIU's	(137)	
IMU DIU's	(20)	
Maintenance Recorder	(100)	
Input/Output Control Unit	(24)	
Data Bus	(27)	
Circuitry	(238)	
Local Mounting Structure	(32)	
Equipment Bay Structure	(106)	
Communications & Navaids	[929]	2.13-13
S-band Equipment	(102)	
Audio Control Center	(36)	
Remote Intercom	(7)	
UHF Transceiver	(24)	
UHF Antenna	(26)	
UHF Ant Window & Instl.	(30)	2.13-29
S-band Antenna	(9)	
DME Receiver	(90)	
DME Antenna	(4)	
DME Ant Window & Instl.	(50)	2.13-30
Glide Slope Receiver	(12)	
Glide Slope Antenna	(6)	
GS Ant Window & Instl.	(32)	2.13-30
VOR/Localizer Receiver	(60)	
VOR/LOC Antenna	(32)	

2.13. Avionics - Cont.

		Page No.
Communications & Navaids Cont.		
VOR/LOC Ant Window & Instl.	(66)	2.13-31
Radio Altimeter	(63)	
Radio Alt. Antenna	(6)	
Radio Alt. Ant. Window & Instl.	(71)	2.13-31
Circuitry	(117)	
Local Mounting Structure	(20)	
Equipment Bay Structure	(66)	
Displays and Controls	[1015]	
Center Front Panel	(107)	2.13-16
Command Pilot Panel	(131)	2.13-17
Pilot Panel	(128)	2.13-18
Command Pilot Obd Panel	(29)	2.13-20
Pilot Obd Panel	(21)	2.13-21
Center Console Panel	(145)	2.13-22
Floor Area	(90)	2.13-23
Overhead Panels	(30)	2.13-24
Docking Station	(13)	2.13-24
Window Frame Mount	(6)	2.13-24
Local Mounting Struct.	(29)	2.13-24
Cockpit Panels	(95)	2.13-24
Circuitry	(191)	2.13-24
Contingency	[599]	2.13-3

2.13 AVIONICS

GENERAL - The Avionics System is a fully integrated electronics system which performs the matrix of system functions outlined on page 2.13-5. The basic system is compatible with a 120 VDC power source and a liquid Freon cooling loop (Reference Sections 2.9 and 2.14). The Data Management, Displays and Controls provide the necessary data link between avionics subsystems, as well as, provides monitoring and control capability of other Orbiter systems thru instrumentation pick-ups provided with each subsystem assembly.

Basic system design criteria is FO, FO, FS with the exception of Communications and some Navigation equipment (an official level I deviation has been granted for these items). There is essentially total commonality of Orbiter and Booster system components. The number of units and type of equipments vary slightly due to differences in mission requirements (see Part III, Sect. 2.13 for Booster Avionics).

METHODOLOGY - System components are patterned after existing hardware, and wherever possible modified "off-the-shelf" equipment is used. Numerous Requests for Technical Information (RFTI) have been sent to candidate vendors and a wealth of weight and design data has been collected to verify the component weight data given on the following pages.

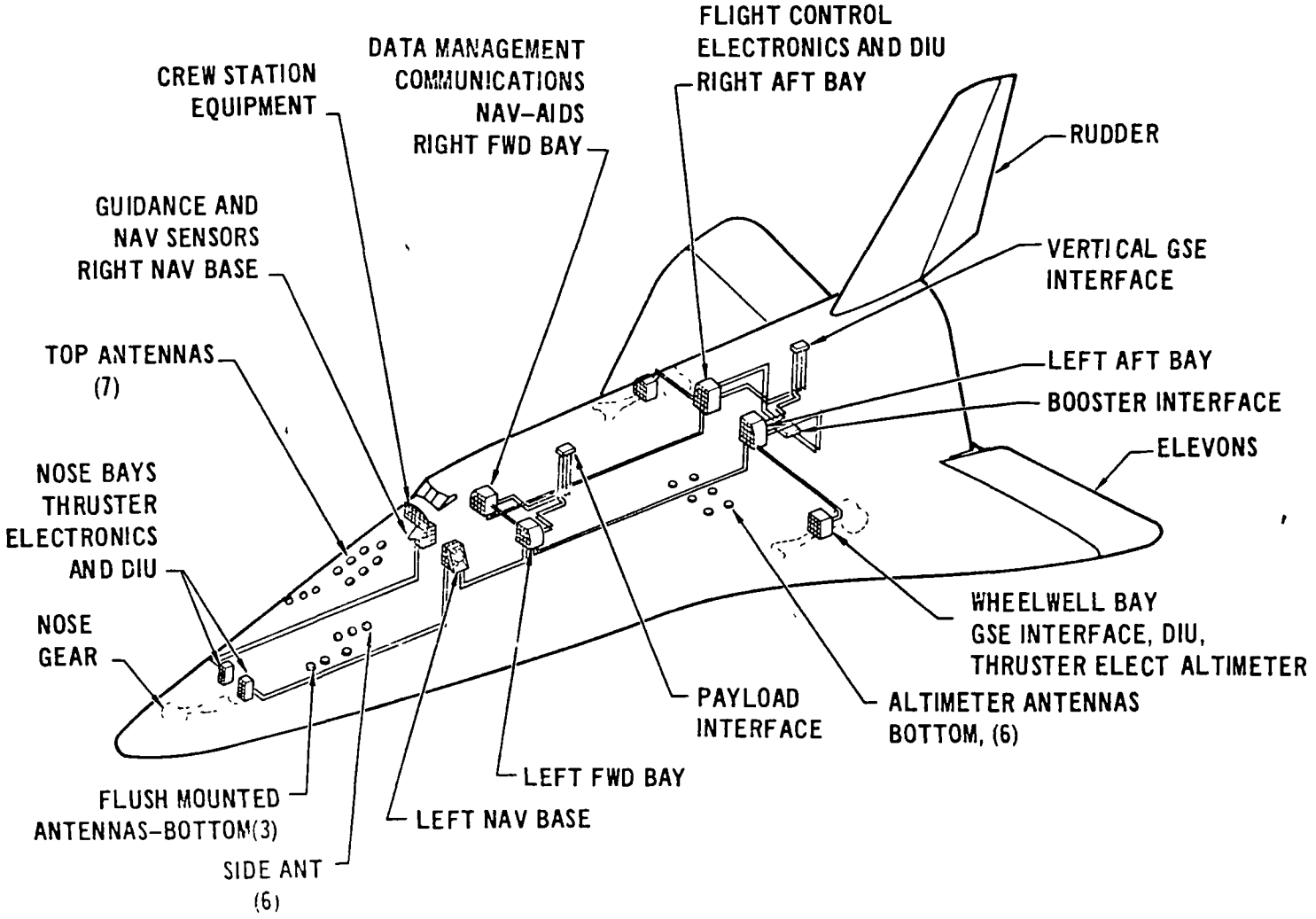
Installation provisions are based on empirical methods given on pages 2.13.39 and 2.13.40. The weight equation for circuitry, i.e. $W_{Circ} = .039 \times (W_{EQ})^{1.298}$ is from Tech. Paper No. 514, SAWE, Inc. "Unmanned Spacecraft Weight Estimation Handbook" by Donald R. Pence, May 1965. A cursory check of the overall spacecraft circuitry requirements has been made and verifies the general weight allocations calculated by this method.

Following NASA Technical Directive No. 2493 for Avionics System Reporting Format, an additional line item system breakdown is supplied on pages 2.13.32 and 2.13.33.

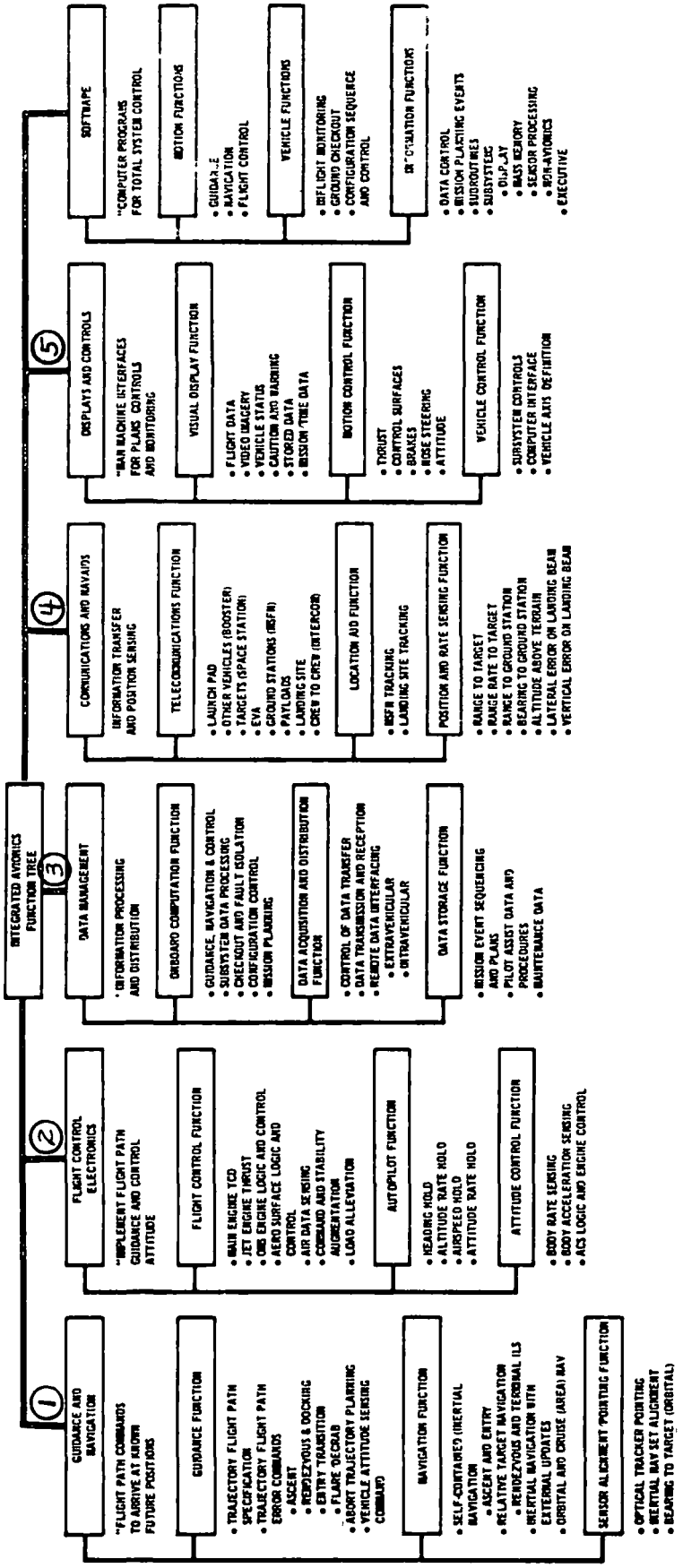
Based on data shown in Section 1.0, 599 pounds is allowed for contingency.

AVIONICS EQUIPMENT ARRANGEMENT

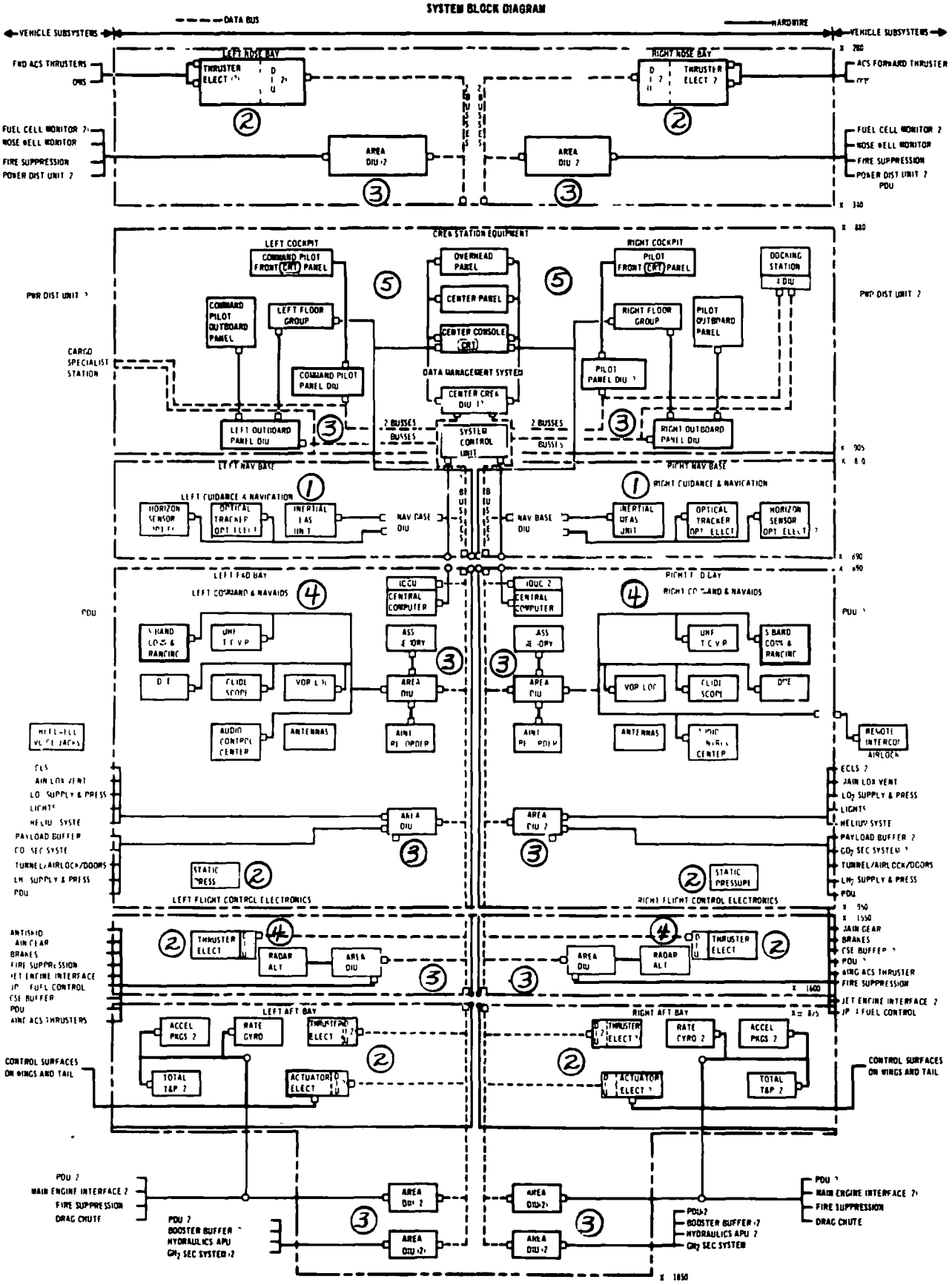
POGP
314-371 A

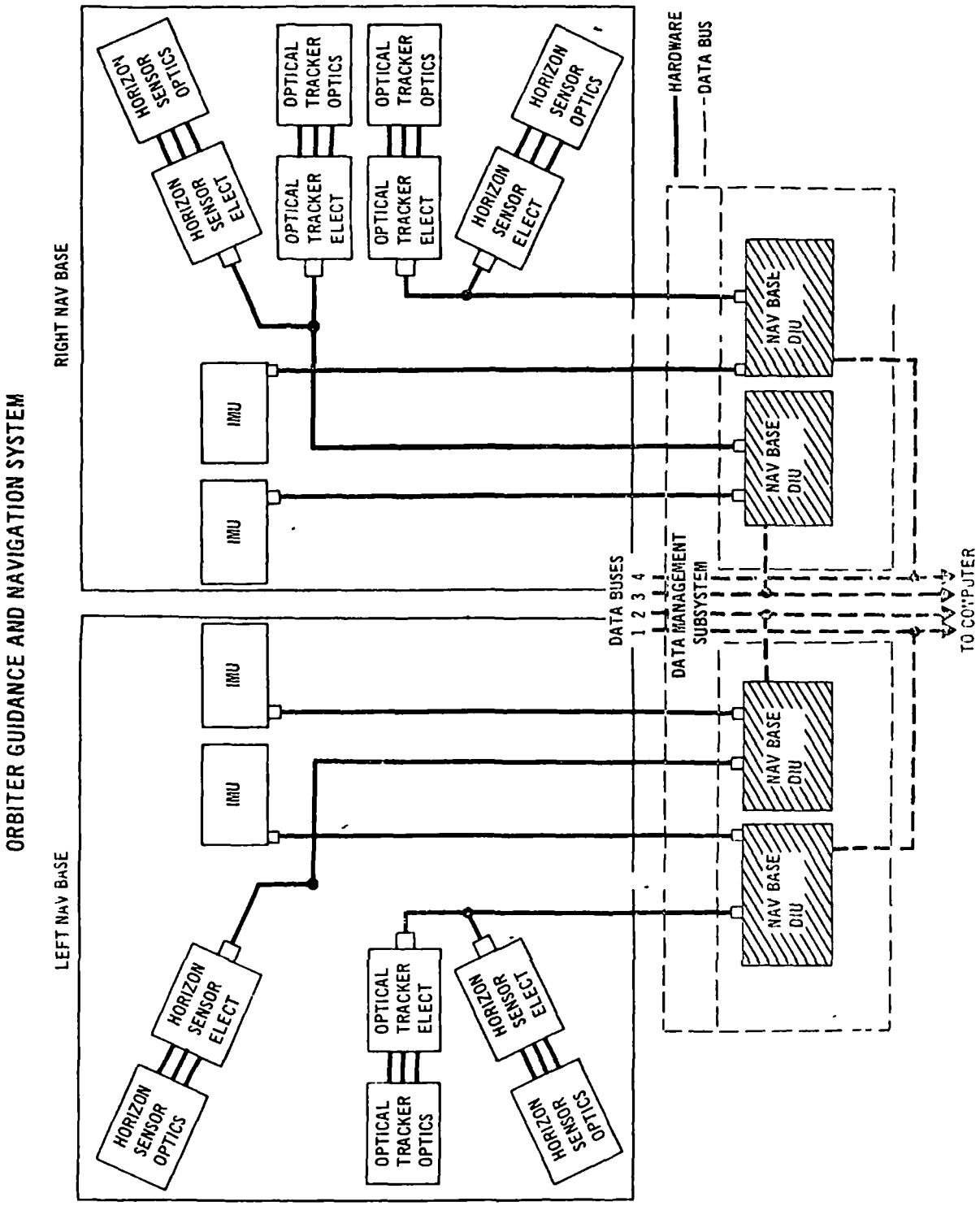


AVIONICS FUNCTIONS



ORBITER AVIONICS
SYSTEM BLOCK DIAGRAM



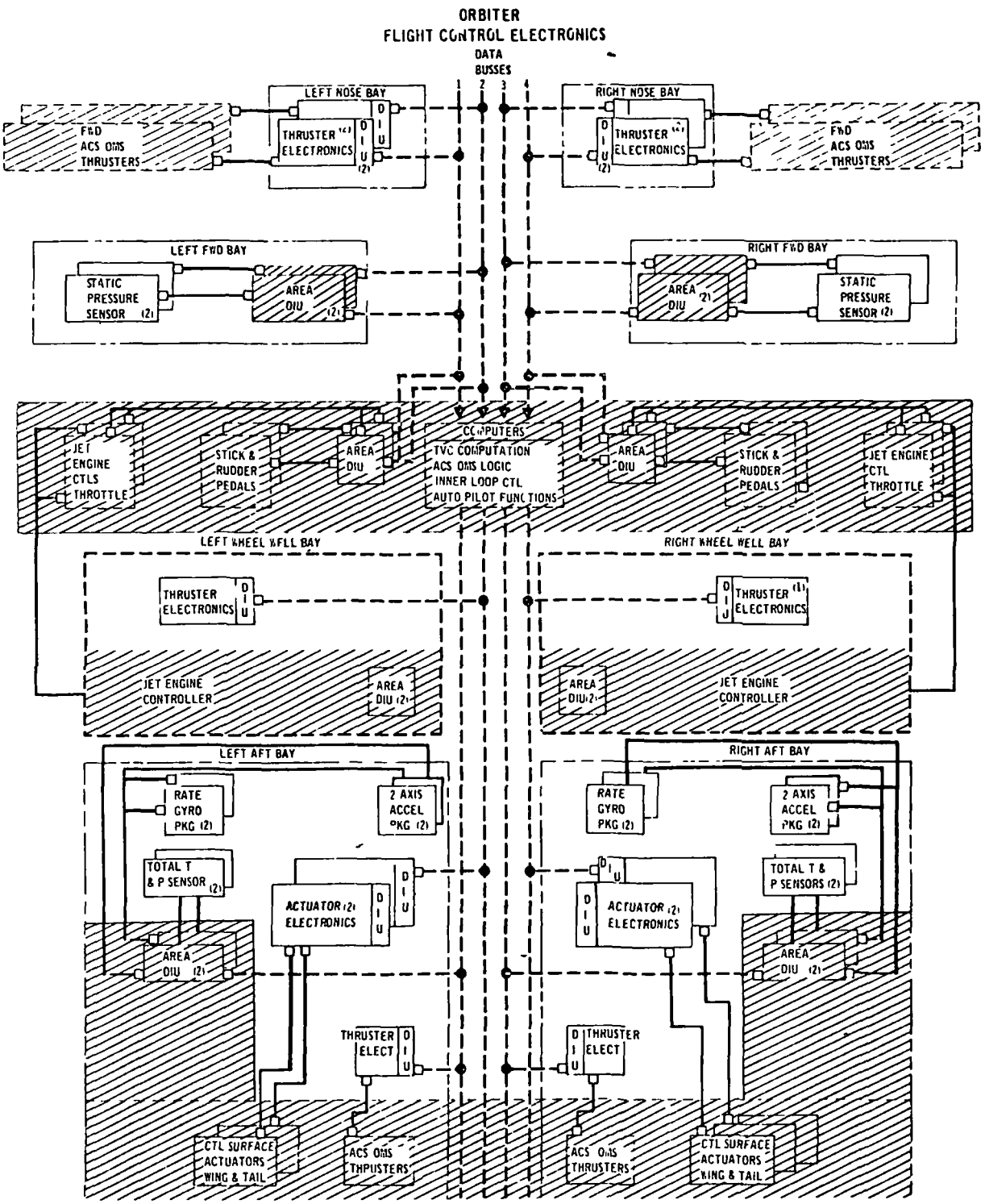

ORBITER GUIDANCE AND NAVIGATION SYSTEM
RIGHT NAV BASE
LEFT NAV BASE
HORIZON SENSOR OPTICS
HORIZON SENSOR ELECT
OPTICAL TRACKER OPTICS
OPTICAL TRACKER ELECT
IMU
NAV BASE DIU
DATA BUSES 1 2 3 4
DATA MANAGEMENT SUBSYSTEM
TO COMPUTER
HARDWARE
DATA BUS

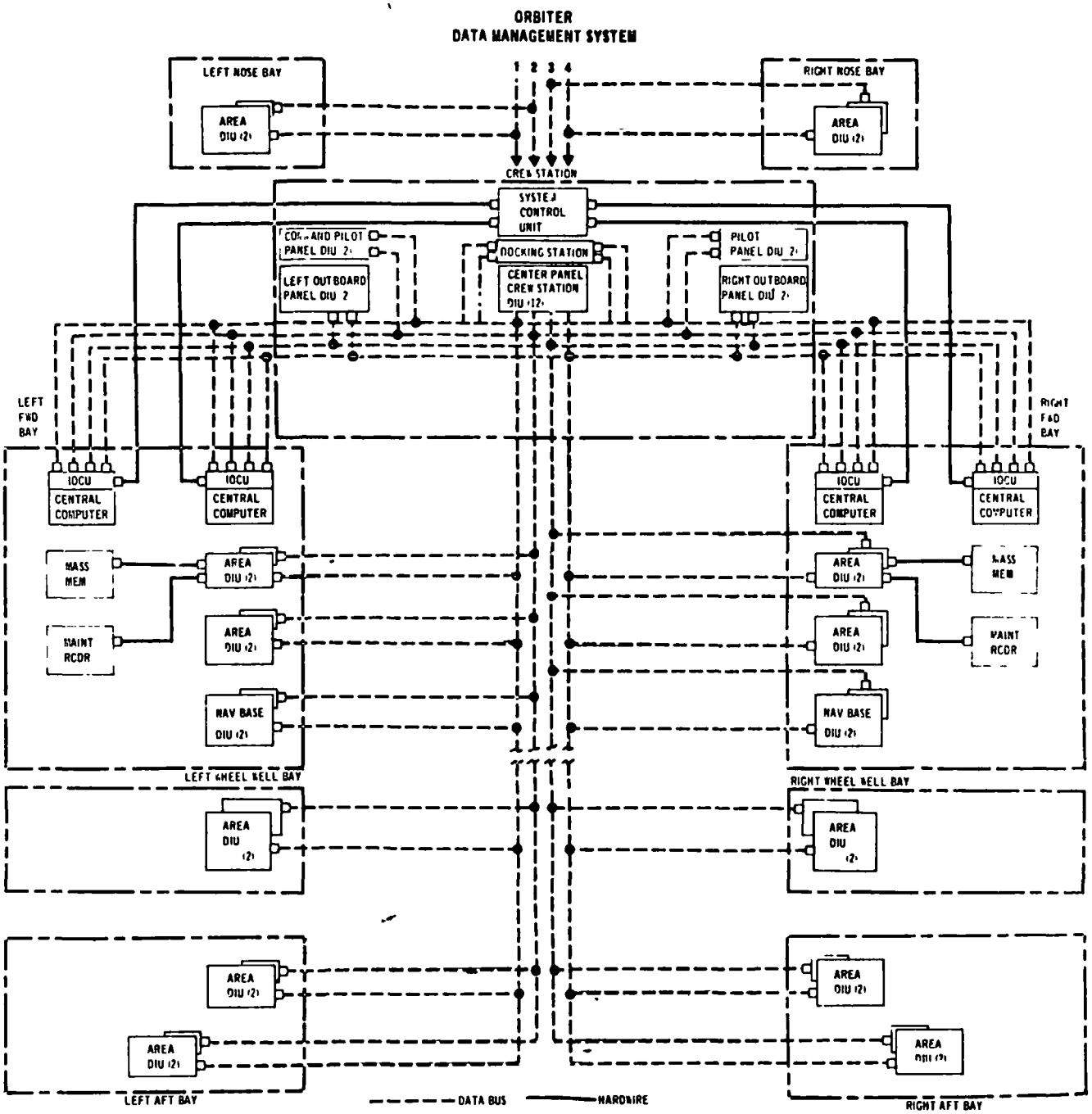
GROUP WEIGHT STATEMENT

	UNITS	CIRCUITRY	COOLING	ANTENNAS	INSTALL.		
2.13. AVIONICS	(2430)	(652)	(N/A)	(83)	(824)		4588
GUID/NAV	292	62			162	516	
FLIGHT CONTROL	224	44			59	327	
DATA MANAGEMENT	826	238			138	1202	
COMMUNICATE	394	117		83	335	929	
CONFIG. SEQ,	SEE DATA MANAGEMENT						
INSTRUMENTATION	"	"	"				
DISPLAYS	694	191			130	1015	
CONTINGENCY						599	

WEIGHT SUBSTANTIATION

ITEM	REF. NO. PG. 2.13-34	UNIT WEIGHT	QTY	TOTAL WEIGHT
GUIDANCE & NAVIGATION	1.			
INERTIAL MEASUREMENT UNIT	2.	35	4	140
STAR TRACKER	3.	40	3	120
HORIZON SENSOR	4.	8	4	32
SUBTOTAL EQUIPMENT				(292)
NAVIGATION BASE	5.	40	2	80
SUBTOTAL MOUNT'D EQUIP.				(372)
CIRCUITRY WT = $.039(292)^{1.298}$ =				62
LOCAL MTG. STR. WT = $.412(372)^{.65}$ =				19.
EQ. BAY STR. WT. = $1.35(372)^{.65}$ =				63
TOTAL GUIDANCE & NAVIGATION (SEE BLOCK DIAG PG 2.13-7)				516 LB.

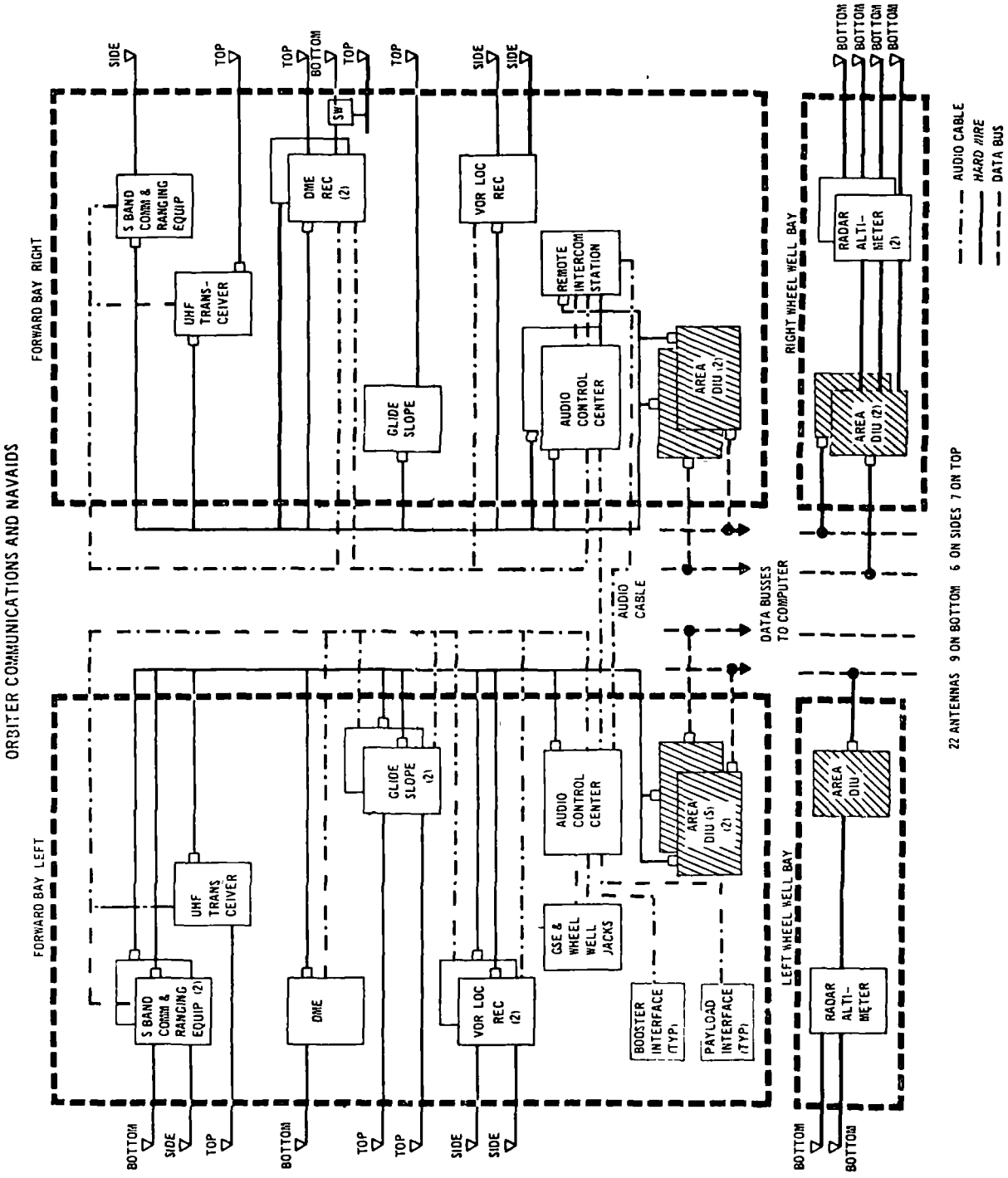

ORBITER
FLIGHT CONTROL ELECTRONICS
DATA BUSSES
1 2 3 4
LEFT NOSE BAY
RIGHT NOSE BAY
FWD ACS OMS THRUSTERS
THRUSTER ELECTRONICS (2)
D I U (2)
LEFT FWD BAY
RIGHT FWD BAY
STATIC PRESSURE SENSOR (2)
AREA DIU (2)
COMPUTERS
TVC COMPUTATION
ACS OMS LOGIC
INNER LOOP CTL
AUTO PILOT FUNCTIONS
JET ENGINE CTLS THROTTLE
STICK & RUDDER PEDALS
LEFT WHEEL WELL BAY
RIGHT WHEEL WELL BAY
JET ENGINE CONTROLLER
LEFT AFT BAY
RIGHT AFT BAY
RATE GYRO PKG (2)
2 AXIS ACCEL PKG (2)
TOTAL T & P SENSOR (2)
TOTAL T & P SENSORS (2)
ACTUATOR (2) ELECTRONICS
THRUSTER ELECT
CTL SURFACE ACTUATORS WING & TAIL
ACS OMS THRUSTERS


ORBITER
DATA MANAGEMENT SYSTEM
LEFT NOSE BAY
AREA DIU (2)
1 2 3 4
RIGHT NOSE BAY
AREA DIU (2)
CREW STATION
SYSTEM CONTROL UNIT
COMMAND PILOT PANEL DIU 2
DOCKING STATION
PILOT PANEL DIU 2
LEFT OUTBOARD PANEL DIU 2
CENTER PANEL CREW STATION DIU (2)
RIGHT OUTBOARD PANEL DIU 2
LEFT FWD BAY
RIGHT FWD BAY
IOCU
CENTRAL COMPUTER
MASS MEM
MAINT RCDR
AREA DIU (2)
NAV BASE DIU (2)
LEFT WHEEL WELL BAY
RIGHT WHEEL WELL BAY
LEFT AFT BAY
RIGHT AFT BAY
DATA BUS
HARDWIRE

WEIGHT SUBSTANTIATION

ITEM	REF. NO. PG 2.13-34,-35	UNIT WEIGHT	QTY	TOTAL WEIGHT
FLIGHT CONTROL SYSTEM	6. (SEE BLOCK DIAG PG. 2.13.-9)			
THRUSTER ELECT. - FWD	7.	7	6	42
THRUSTER ELECT. -AFT	7.	13	2	26
ACTUATOR ELECTRONICS	8.	28.5	4	114
RATE GYRO PACKAGE	9.	4	4	16
TOT TEMP. & PRESS SNSR	10.	2.5	4	10
ACCELEROMETER	11.	1.5	4	6
STATIC PRESS. SENSOR	12.	2.5	4	10
SUB TOTAL EQUIPMENT				(224)
CIRCUITRY WT. = $.039(224)^{1.298}$ =				44
LOCAL MTG. STR WT = $.412(224)^{.65}$ =				14
EQ. BAY STR. WT. = $1.35(224)^{.65}$ =				45
TOTAL FLIGHT CONTROL SYSTEM				327 LB
DATA MANAGEMENT	13. (SEE BLOCK DIAG PG. 2.13-10)			
CENTRAL COMPUTER	14.	85.	4	340
SYSTEM CONTROL UNIT	15.	7	1	7
MASS MEMORY	18.	16	2	32
AREA DIU'S	17.	5.8	24	139
CREW STATION DIU'S	17.	5.7	24	137
IMU DIU'S	17.	5.0	4	20
MAINTENANCE RECORDER	19.	50.	2	100
INPUT/OUTPUT CONTROL UNIT	16.	6	4	24
DATA BUS	*			27
SUBTOTAL EQUIPMENT				(826)
CIRCUITRY WT = $039(826)^{1.298}$ =				238
LOCAL MTG. STR. WT. = $.412(826)^{.65}$ =				32
EQ. BAY STR. WT. = $1.35(826)^{.65}$ =				106
TOTAL DATA MANAGEMENT				1202 LB

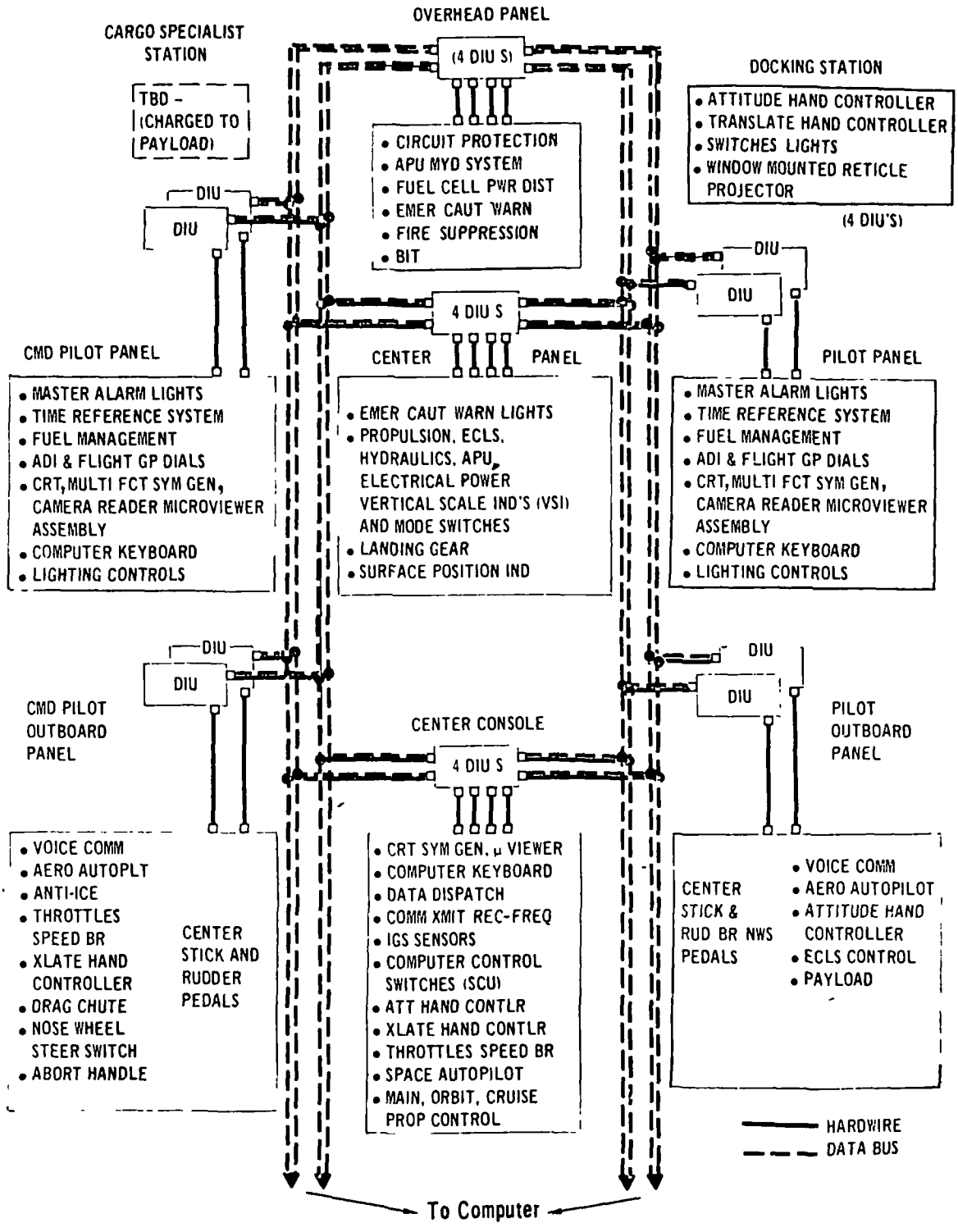
* BASED ON GROSS EST OF 1500' (4) WIRE TWISTED SHEILDED @ 18#/1000'.


ORBITER COMMUNICATIONS AND NAVAIDS
FORWARD BAY RIGHT
FORWARD BAY LEFT
RIGHT WHEEL WELL BAY
LEFT WHEEL WELL BAY
S BAND COMM & RANGING EQUIP
UHF TRANS-CEIVER
DME REC (2)
SW
VOR LOC REC
GLIDE SLOPE
REMOTE INTERCOM STATION
AUDIO CONTROL CENTER
AREA DIU (2)
RADAR ALTI-METER (2)
AUDIO CABLE
DATA BUSSES TO COMPUTER
GLIDE SLOPE (2)
AREA DIU (5) (2)
AREA DIU
S BAND COMM & RANGING EQUIP (2)
DME
VOR LOC REC (2)
GSE & WHEEL WELL JACKS
BOOSTER INTERFACE (TYP)
PAYLOAD INTERFACE (TYP)
RADAR ALTI-METER
22 ANTENNAS 9 ON BOTTOM 6 ON SIDES 7 ON TOP
AUDIO CABLE
HARD WIRE
DATA BUS
SIDE
TOP
BOTTOM

WEIGHT SUBSTANTIATION

ITEM	REF NO. PG. 2.13-35, -36	UNIT WEIGHT	QTY	TOTAL WEIGHT
COMMUNICATIONS & NAVAIDS	20. (SEE BLOCK DIAG PG 2.13-12)			
S-BAND EQUIPMENT	21	34	3	102
AUDIO CONTROL CENTER	22.	12	3	36
REMOTE INTERCOM	23.	7	1	7
UHF TRANSCEIVER	24.	12	2	24
UHF ANTENNA	25.	13	2	26
UHF ANT WINDOW (REF. PG 2.13-29)		15	2	30
S-BAND ANTENNA	21.	3	3	9
DME RECEIVER	26.	30	3	90
DME ANTENNA	25.	1	4	4
DME ANT WINDOW (REF. PG 2.13-30)		12.5	4	50
GLIDE SLOPE RECEIVER	27 & 28	4	3	12
GLIDE SLOPE ANTENNA	25.	2	3	6
GS ANT WINDOW (REF. PG. 2.13-30)		10.7	3	32
VOR/LOCALIZER RECEIVER	27 & 28	20	3	60
VOR/LOC ANTENNA	25.	8	4	32
VOR/LOC ANT. WINDOW (REF. PG 2.13-31)		16.5	4	66
RADIO ALTIMETER	29.	21	3	63
ALTIMETER ANTENNA	25.	1	6	6
ALT. ANT. WINDOW (REF. PG 2.13-31)		11.8	6	71
SUBTOTAL EQUIPMENT				(726)
CIRCUITRY WT = .039 (726 − 249 # ANT WIND'S)$^{1.298}$ =				117
LOCAL MTG. STR. WT. = .412 (726 − 332 # ANT & WIND'S)$^{.65}$ =				20
EQ. BAY STR. WT = 1.35 (726 − 332 # ANT & WIND'S)$^{.65}$ =				66
TOTAL COMMUNICATIONS & NAVAIDS				923.8

ORBITER DISPLAY/CONTROL SUBSYSTEM



ORBITER DISPLAYS AND CONTROLS

1 DUAL DME
2 RATE OF DESCENT INDICATOR
3 HSI
4 RADIO ALTIMETER
5 CRT
6 ANGLE OF ATTACK
7 COMPUTER KEYBOARD
8 ACCELEROMETER
9 TIME REFERENCE SYSTEM
10 LIGHTING CONTROLS
11 MACH/AIR SPEED INDICATOR
12 FLIGHT DIRECTOR REFERENCE
13 MASTER ALARMS
14 ATTITUDE DISPLAY INDICATOR
15 EVENT TIMER
16 PRESSURE ALTIMETER
17 STANDBY ATTITUDE INDICATOR
18 FUEL MANAGEMENT
19 EMERGENCY CAUTION & WARNING INDICATORS
20 PROPULSION INDICATORS
21 APU PANEL
22 HYDRAULICS PANEL
23 SURFACE POSITION INDICATOR
24 LANDING GEAR CONTROL
25 FUEL CELL PANEL
26 ECLS PANEL

WEIGHT SUBSTANTIATION

SEE PAGE 2.13-37 SOURCE DATA & REFERENCES 30a THRU m.

DISPLAYS & CONTROLS ~ REF. PG'S. 2.13-14, -15, & -19 FOR ITEM NO'S & BLOCK DIAG.

ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	CENTER FRONT PANEL			(106.6)
(20)	PROPULSION PANEL			
	VERT. SCALE IND. (4 TAPES EA)	5.2	5	26.
	PUSH BUTTON	.1	20	2.
(26)	ECLS PANEL			
	VERT. SCALE IND. (4 TAPES EA)	5.2	5	26.
	PUSH BUTTON	.1	8	.8
	PENLITE	.1	6	.6
	TOGGLE SWITCH	.1	9	.9
	TWIST KNOB	.2	3	.6
(21)	APU/ALT. PANEL			
	VERT. SCALE IND. (2 SCALES EA)	2.5	3	7.5
	TOGGLE SWITCH	.1	12	1.2
	PENLITE	.1	6	.6
(23)	SURF. POSITION INDICATOR	5.0	1	5.0
(24)	LAND GEAR LEVER/LIGHTS	3.0	1	3.0
(25)	ELECT. POWER PANEL			
	VERT. SCALE IND (2 SCALES EA)	2.5	4	10.
	TOGGLE SWITCH	.1	12	1.2
	PENLITE	.1	16	1.6
(22)	HYDRAULICS/BRAKES PANEL			
	VERT. SCALE IND (2 SCALES EA)	2.5	4	10.
	TOGGLE SWITCH	.1	10	1.
	PENLITE	.1	11	1.1
(19)	EMERGENCY/CAUTION/WARNING			
	PUSH BUTTON	.1	75 (EST)	7.5

WEIGHT SUBSTANTIATION

DISPLAYS & CONTROLS - REF. PG'S 2.13-14, -15 & -19 FOR ITEM NO'S &. BLOCK DIAG.

ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	COMMAND PILOT FRONT PANEL			(131.3)
(9)	TIME REFERENCE SYS.			
	GMT IND/ELECT	1.5	1	1.5
	MET IND/ELECT	1.5	1	1.5
(15)	EVENT IND/ELECT.	1.5	1	1.5
	START/STOP/SLEW SW/ELECT	.5	1	.5
(18)	FUEL MANAGEMENT PANEL			
	INDICATOR	1.	2	2.
	TOGGLE SWITCH	.1	3	.3
(13)	MASTER ALARM LITES	.1	2	.2
(12)(14)(17)	ATTITUDE DISPLAY IND/MODE SW.	11.	1	11.
	FLIGHT GROUP DIAL INDICATORS			
(4)	RADIO ALTIMETER	2.5	1	2.5
(11)	MACH/AIRSPEED	3.5	1	3.5
(6)	ANGLE-OF-ATTACK	2.9	1	2.9
(8)	ACCELEROMETER	2.0	1	2.0
(2)	RATE OF DESCENT	2.3	1	2.3
(16)	PRESS. ALTIMETER	2.0	1	2.0
(1)	DISTANCE MEASURE(DME) DIAL	2.5	1	2.5
(3)	HORIZ SITUATION IND (HSI)	6.5	1	6.5
(5)	VIDEO DISPLAYS			
	CATHODE RAY TUBE IND.	31.	1	31.
	MULTIFUNCTION SYM. GEN.	30.	1	30.
	CAMERA READER MICROVIEWER	14.	1	14.
	VIDEO DISPLAY SYS. CABLE	10.	1	10.
(7)	COMPUTER KEYBOARD	3.	1	3.
(10)	LIGHTING CONTROLS			
	TOGGLE SWITCH	.1	2	.2
	TWIST KNOB	.2	2	.4

WEIGHT SUBSTANTIATION

DISPLAYS & CONTROLS – REF. PG's 2.13-14, -15 & -19 FOR ITEM NO'S & BLOCK DIAG.

ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	PILOT FRONT PANEL			(127.8)
(9)	TIME REFERENCE SYS.			
	GMT IND/ELECT.	1.5	1	1.5
	MET IND/ELECT.	1.5	1	1.5
(15)	EVENT IND/ELECT.	1.5	1	1.5
	START/STOP/SLEW SW/ELECT	.5	1	.5
(13)	MASTER ALARM LITES	.1	2	.2
(12)(14)	ATTITUDE DISPLAY IND/MODE SW	9.	1	9.
	FLIGHT GROUP DIAL INDICATORS			
(4)	RADIO ALTIMETER	2.5	1	2.5
(11)	MACH/AIRSPEED	3.5	1	3.5
(6)	ANGLE-OF-ATTACK	2.9	1	2.9
(8)	ACCELEROMETER	2.0	1	2.0
(16)	PRESS. ALTIMETER	2.0	1	2.0
(2)	RATE OF DESCENT	2.3	1	2.3
(1)	DISTANCE MEASURE(DME)DIAL	2.5	1	2.5
(3)	HORIZ. SITUATION IND(HSI)	6.5	1	6.5
(5)	VIDEO DISPLAYS			
	CATHODE RAY TUBE IND	31.	1	31.
	MULTIFUNCTION SYM GEN.	30.	1	30.
	CAMERA READER MICROVIEWER	14.	1	14.
	VIDEO DISPLAY SYS. CABLE	10.	1	10.
(7)	COMPUTER KEYBOARD	3.	1	3.
(10)	LIGHTING CONTROLS			
	TOGGLE SWITCH	.1	4	.4
	TWIST KNOB	.2	5	1.

ORBITER DISPLAYS & CONTROLS (Continued)

27 AUTOPILOT
28 VOICE TRANSMITTER SELECT
29 VOICE CONTROL CENTER
30 WINDSHIELD AND DE-ICE CONTROLS
31 TRANSLATION CONTROL
32 TRANSLATION CONTROL SYSTEM SELECT
33 THROTTLES
34 ABORT CONTROL
35 AERODYANMIC TRIMS
36 MASTER POWER (ON PAD DE-ACTIVATION)
37 IMU CONTROL PANEL
38 NAVIGATION MODE SELECTS
39 COMPUTER CONTROL
40 GUIDANCE MODE SELECTOR
41 FREQUENCY SELECTOR
42 COMMUNICATIONS CONTROL
43 ATTITUDE CONTROL
44 ORBIT ATTITUDE MODES
45 ORBIT PROPULSION PANEL
46 HORIZON SCANNERS CONTROLS
47 STAR TRACKERS CONTROLS
48 MAIN ENGINES PANEL
49 DATA DISPATCH PANEL
50 CRUISE ENGINES PANEL
51 REACTION ENGINES ISOLATION PANEL
52 DOOR-RADIATOR-PAYLOAD DEPLOY PANEL
53 ECLS VALVING CONTROL

WEIGHT SUBSTANTIATION

DISPLAYS & CONTROLS ~ REF. PG'S 2.13-14, -15 & -19 FOR ITEM NO'S & BLOCK DIAG.

ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	COMMAND PILOT OUTBOARD PANEL			(28.8)
(28)(29)	VOICE COMM. CONTROL			
	TOGGLE SWITCH	.1	12	1.2
	TWIST KNOB	.2	6	1.2
(27)	AERO AUTOPILOT PANEL			
	PUSH BUTTON	.1	4	.4
	TOGGLE SWITCH	.1	7	.7
	PENLITE	.1	2	.2
	ALT NUMERIC IND/SET SW.	1.	1	1.
	SPEED NUMERIC IND/SET SW.	1.	1	1.
	HEADING NUMERIC IND/SET SW	1.	1	1.
(30)	WINDSHIELD/ANTI-ICE			
	TOGGLE SWITCH	.1	5	.5
(31)(32)	TRANSLATIONAL HAND CONTROLLER	5.	1	5.
(33)	THROTTLES			
	THROTTLE WITH SP. BR. TRIM SW.	6.	2	12.
	ENGINE TRIM SWITCH	.2	4	.8
(34)	ABORT HANDLE/LIGHTS	3.	1	3.
(35)	AERO TRIM SWITCH	.1	3	.3
(36)	MASTER POWER (ON PAD DE-ACT)	.5	1	.5

WEIGHT SUBSTANTIATION

DISPLAYS & CONTROLS – REF. PG'S 2.13-14, -15, & -19 FOR ITEM NO'S & BLOCK DIAG.

ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	PILOT OUTBOARD PANEL			(21.5)
(28)(29)	VOICE COMM. CONTROL			
	TOGGLE SWITCH	.1	12	1.2
	TWIST KNOB	.2	6	1.2
(27)	AERO AUTOPILOT PANEL			
	PUSH BUTTON	.1	4	.4
	TOGGLE SWITCH	.1	7	.7
	PENLITE	.1	2	.2
	ALT NUMERIC IND/SET SW.	1.	1	1.
	SPEED NUMERIC IND/SET SW.	1.	1	1.
	HEADING NUMERIC IND/SET SW.	1.	1	1.
(43)	ROTATIONAL HAND CONTROLLER	6.	1	6.
(53)	ECLS PANEL			
	TWIST KNOB	.2	12	2.4
(52)	PAYLOAD DISP/CONT PANEL			
	TOGGLE SWITCH	.1	4	.4
	DIAL INDICATORS	2.	3	6.

WEIGHT SUBSTANTIATION

DISPLAYS & CONTROLS ~ REF. PG's 2.13-14, -15 & -19 FOR ITEM NO.'s & BLOCK DIAG.

ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	CENTER CONSOLE PANEL			(145.3)
(5)	VIDEO DISPLAYS			
	CATHODE RAY TUBE IND.	31.	1	31.
	MULTIFUNCTION SYM GEN.	30.	1	30.
	CAMERA READER MICROVIEWER	14.	1	14.
	VIDEO DISPLAY SYS CABLE	10.	1	10.
(7)	COMPUTER KEYBOARD	3.	1	3.
(41) (42)	COMMUNICATIONS/NAVAIDS PANEL			
	TOGGLE SWITCH	.1	12	1.2
	PUSH BUTTON	.1	7	.7
	THUMBWHEEL SW/IND.	.33	30	10.
(39)	COMPUTER CONTROL PANEL			
	PUSH BUTTON	.1	4	.4
	TOGGLE SWITCH	.1	4	.4
(37)	IMU CONTROL PANEL			
	PUSH BUTTON	.1	12	1.2
(46)	HORIZON SENSOR PANEL			
	PUSH BUTTON	.1	9	.9
(38)	NAV UPDATE PANEL			
	TOGGLE SWITCH	.1	2	.2
	PENLITE	.1	2	.2
(47)	STAR TRACKER PANEL			
	PUSH BUTTON	.1	6	.6
(49)	DATA DISPATCH			
	PUSH BUTTON	.1	9	.9
(48)	MAIN ENGINE CONTROL			
	TOGGLE SWITCH	.1	3	.3
	PENLITE	.1	4	.4
	PUSH BUTTON	.1	8	.8

WEIGHT SUBSTANTIATION

DISPLAYS & CONTROLS ~ REF. PG'S 2.13-14, -15 & -19 FOR ITEM NO'S & BLOCK DIAG.

ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	CENTER CONSOLE PANEL ~ CON'T			
(50)	ABES MANAGEMENT PANEL			
	TOGGLE SWITCH	.1	2	.2
	PUSH BUTTON	.1	8	.8
	TRIM SWITCH	.1	4	.4
(44)	SPACE AUTOPILOT PANEL			
	PUSH BUTTON	.1	9	.9
(45)	ORBIT MANEUVER & ACPS PANEL			
	TOGGLE SWITCH	.1	18	1.8
(51)	ACPS THRUSTER ISOLATION			
	TOGGLE SWITCH	.1	33	3.3
	PENLITE	.1	66	6.6
(35)	AERO TRIM SWITCH	.1	3	.3
(31) (32)	TRANSLATIONAL HAND CONTROLLER	5.	1	5.
(43)	ROTATIONAL HAND CONTROLLER	6.	1	6.
(33)	THROTTLES			
	THROTTLE WITH SP. BR. TRIMSW.	6.	2	12.
	ENGINE TRIM SWITCH	.2	4	.8
(40)	GUIDANCE MODE SELECTOR	1.	1	1.
	FLOOR AREA			(90.)
	COMMAND PILOT CENTER STICK	20.	1	20.
	PILOT CENTER STICK	20.	1	20.
	CMD PLT RUD/BR/NWS PEDALS	25.	1	25.
	PILOT RUD/BR/NWS PEDALS	25.	1	25.

WEIGHT SUBSTANTIATION

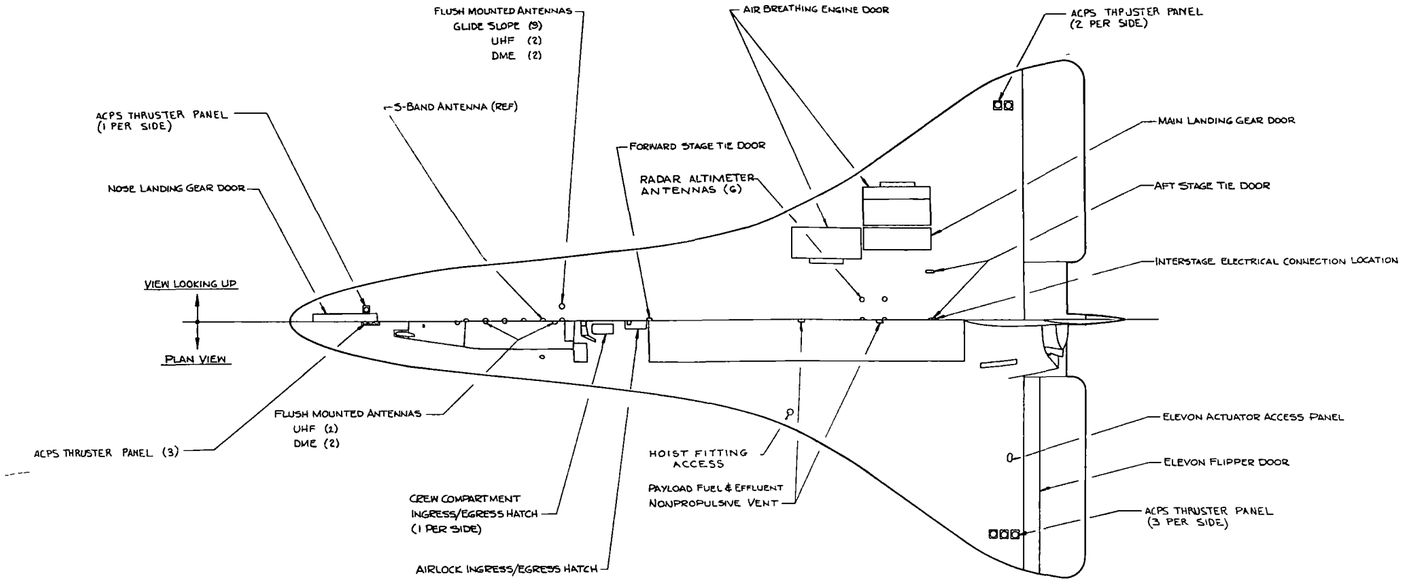
DISPLAYS & CONTROLS ~ REF PG'S 2.13-14, -15 & -19 FOR ITEM NO'S & BLOCK DIAG.

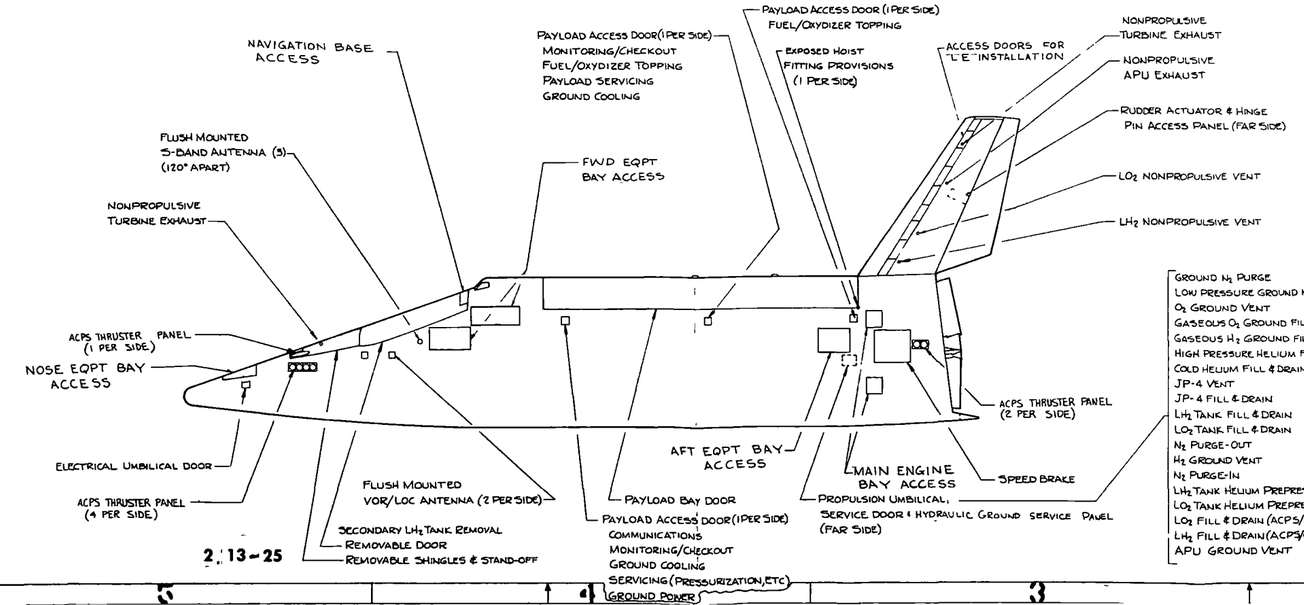
ITEM NO.	ITEM	UNIT WEIGHT	QTY	TOTAL WEIGHT
	OVERHEAD PANEL (ESTIMATED)			(30.)
	CIRCUIT PROTECTION	" ?		4.7
	FUEL CELL AND PWR DISTR.	" ~CNTR FR PNL)		12.8
	BUILT-IN TEST	" ?		5.0
	EMERGENCY/CAUTION/WARNING	(EST ~ CNTR FR PNL)		7.5
	DOCKING STATION			(13.)
	TRANSLATIONAL HAND CONTROLLER	5.	1	5.
	ROTATIONAL HAND CONTROLLER	6.	1	6.
	BAY/PAYLOAD SW & LITES			
	TOGGLE SWITCH	.1	10	1.
	PENLITE	.1	10	1.
	WINDOW FRAME MOUNT			(6.)

SUMMARY

CENTER FRONT PANEL	106.6
COMMAND PILOT FRONT PANEL	131.3
PILOT FRONT PANEL	127.8
COMMAND PILOT OUTBOARD PANEL	28.8
PILOT OUTBOARD PANEL	21.5
CENTER CONSOLE PANEL	145.3
FLOOR AREA	90.0
OVERHEAD PANEL	30.0
DOCKING STATION	13.0
SUBTOTAL EQUIPMENT	(694.3)
WINDOW FRAME MOUNT	6.0
CIRCUITRY WT = $.039(694)^{1.298}$ =	190.5
LOCAL MTG. STR. = $.412(694)^{.65}$ =	29.0
COCKPIT PANELS = $1.35(694)^{.65}$ =	95.0
TOTAL DISPLAYS & CONTROLS	1014.8 LB.

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	CHANGED QUAN & LOCATION OF ANTENNAS, CHANGED L G DR RS TO ONE PIECE, CHANGED VERT FIN & ASSOCIATED ACCESS PANELS, CHANGED FWD EQUIP BAY ACCESS, ADDED NOSE EQUIP BAY ACCESS.	6/3/71	





2.13-25

1 THIS DRAWING COVERS EXTERIOR ML ITEMS SUCH AS:
- ACCESS/SERVICE DOORS AND PANELS
- UMBILICAL DOORS
- HATCHES
- ML MOUNTED EQUIPMENT
- VENT HOLES
- EXHAUST HOLES
- HOIST PROVISIONS
- SPEED BRAKE

NOTES

QTY REQD	QTY REQD FIND NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	STOCK	MATERIAL OR MATERIAL CODE	DRAWING OR SPECIFICATION NO	NOTE NO.	ZONE
				PARTS LIST					

LOFT	DR W. JONES	2/24/71	MCDONNELL DOUGLAS ASTRONAUTICS COMPANY – EASTERN DIVISION
DATA	CHK DR. D. M. [illegible]	3/4/71	MCDONNELL DOUGLAS CORPORATION
LAYOUT	STR DYN [illegible]	3/4/71	
NO.	CH SYS [illegible]	3/4/71	
	PROJ ENGR [illegible]	3/4/71	
TOLERANCE UNLESS NOTED	[illegible]	3/5/71	
.XX = ± .03			
.XXX = ± .010			
FINISH			
SPEC			
CONTR NO.			

DASH NO	FIN. ART QTY REQD	NEXT ASSY	USED ON APPLICATION

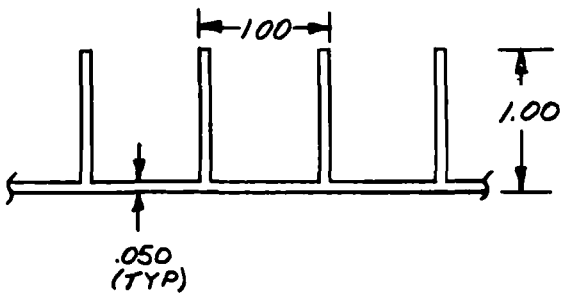
ML DOOR & ACCESS PANEL LOCATIONS-DELTA WING ORBITER

SIZE	CODE IDENT NO.	255BJ00096 REV L 6/3/71
J	76301	
SCALE 1/100	WT	LB SHEET 1 OF 1

DRAWING NUMBER 255BJ00096 REV L
DATE PRINTED

ANTENNA WINDOWS AND MOUNTING

HASTELLOY-X INTEGRALLY STIFFENED PLATE (1 REQ'D)



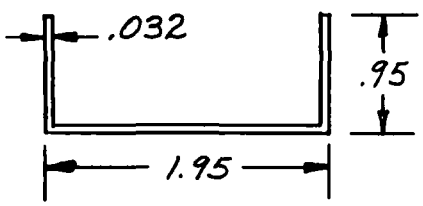
20.0" X 20.0" PANEL

UNIT WT = $.297 \times .05 \times (20.0 \times 20.0 + 20 \times 20.0 \times 1.00)/400$

= .030 LB/IN^2

AREA OF PLATE IS 400 IN^2 LESS AREA OF ANTENNA WINDOW.

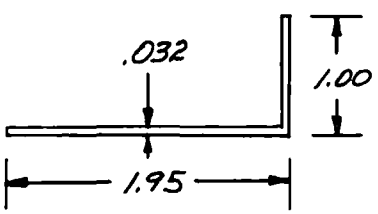
TITANIUM CHANNEL (2 REQ'D)



CHANNEL LENGTH IS MAXIMUM WINDOW DIMENSION.

UNIT WT = $.160 \times .032 \times (.95 + 1.95 + .95)$ = .020 LB/IN

HASTELLOY-X ANGLE (2 REQ'D)

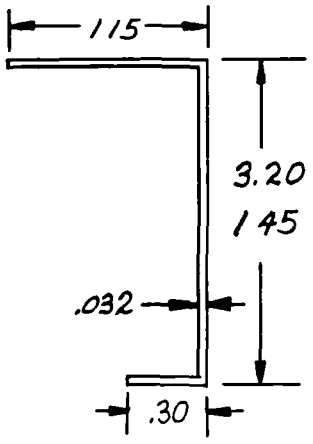


LENGTH = 20.0"

WEIGHT = $[.297 \times .032 \times (1.00 + .95) \times 20.0] \times 2.$ = 1.13 LB.

ANTENNA WINDOWS AND MOUNTING

HASTELLOY WINDOW ENCLOSURE (1 REQ'D)



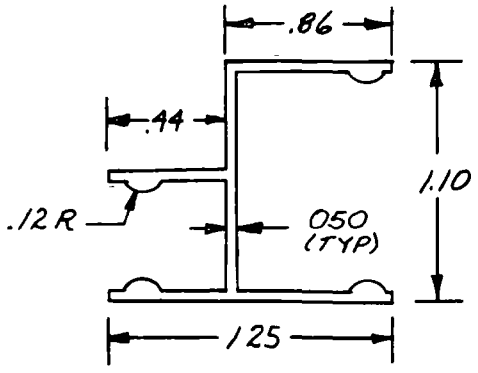
3.20 HIGH TEMPERATURE VERSION
1.45 LOW TEMERATURE VERSION

LENGTH OF ENCLOSURE IS THE PERIMETER OF ANTENNA WINDOW.

UNIT WT = .297 × .032 × (1.15 + 3.20 + .30) = .045 LB/IN (H.T.)

= .297 × .032 × (1.15 + 1.45 + .30) = .028 LB/IN (L.T.)

HASTELLOY WINDOW FRAME (1 REQ'D)



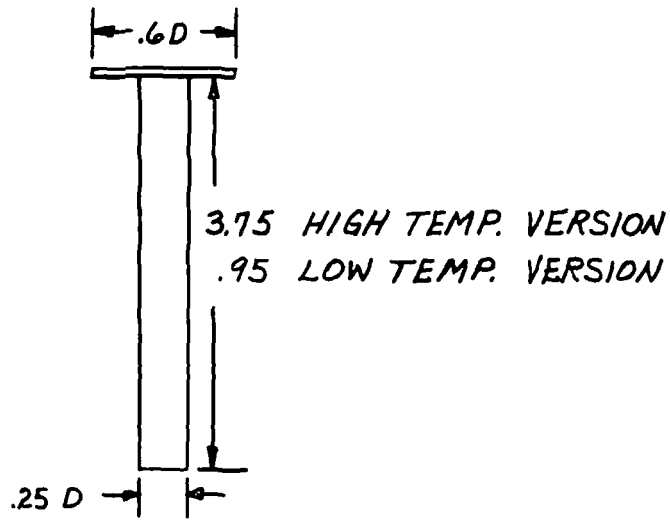
LENGTH OF WINDOW FRAME IS THE PERIMETER OF THE ANTENNA WINDOW.

UNIT WT = .297 × [.050 × (.86 + 1.10 + .44 + 1.25) + 4 × .01]

= .061 LB/IN

ANTENNA WINDOWS AND MOUNTING

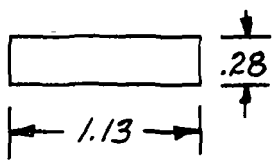
HASTELLOY SPACERS (4 REQ'D)



WEIGHT = .297 × (.049 × 3.72 + .283 × .032) × 4 = .23 LB H.T

= .297 × (.049 × .92 + .283 × .032) × 4 = .07 LB L.T.

LOAD BEARING INSULATION (1 REQ'D)



ASSUME MIN-K 1301, ρ = .012 LB/IN^3.
INSULATION LENGTH IS PERIMETER OF ANTENNA WINDOW.

UNIT WT = .012 × .28 × 1.13 = .004 LB/IN

WINDOW UNIT WEIGHT

HIGH TEMPERATURE VERSION	7.93 LB/FT^2
LOW TEMPERATURE VERSION	3.97 LB/FT^2

ANTENNA WINDOWS AND MOUNTING

UHF ANTENNA 20" DIA. LOW TEMP (2 REQ'D)

AREA = 314 IN² PERIMETER = 63 IN

ITEM	CALCULATION	WEIGHT
PLATE	.030 × (400-314)	2.58
CHANNEL	.020 × 20. × 2	.80
ANGLE		1.13
ENCLOSURE	.028 × 63	1.76
FRAME	.061 × 63	3.84
SPACERS		.07
INSULATION	.004 × 63	.25
SHINGLE	-(1.39 × 400/144)	-3.86
STRUCTURAL PENALTY		(6.57)
WINDOW	3.97 × 314/144	(8.66)
TOTAL ASSEMBLY		(15 23)
TOTAL UHF ANTENNAS		30.46

DME ANTENNA 8.5" DIA LOW TEMP (2 REQ'D)

AREA = 57 IN² PERIMETER = 27 IN.

ITEM	CALCULATION	WEIGHT
PLATE	.030 × (400-57)	10.29
CHANNEL	.020 × 8.5 × 2	.34
ANGLE		1.13
ENCLOSURE	.028 × 27	.76
FRAME	.061 × 27	1.65
SPACERS		.07
INSULATION	.004 × 27	.11
SHINGLE	-(1.39 × 400/144)	-3.86
STRUCTURAL PENALTY		(10.49)
WINDOW	397 × 57/144	(1.57)
TOTAL ASSEMBLY		(12.06)

ANTENNA WINDOWS AND MOUNTING

DME ANTENNA 8.5" DIA HIGH TEMP (2 REQ'D)

ITEM	CALCULATION	WEIGHT
PLATE	.030 × (400-57)	10.29
CHANNEL	.020 × 8.5 × 2	.34
ANGLE		1.13
ENCLOSURE	.045 × 27	1.22
FRAME	.061 × 27	1.65
SPACERS		.23
INSULATION	.004 × 27	.11
SHINGLE	-(1.90 × 400/144)	-5.28
STRUCTURAL PENALTY		(9.69)
WINDOW	7.93 × 57/144	(3.14)
TOTAL ASSEMBLY		(12.83)
TOTAL DME ANTENNAS		49.78

GLIDE SLOPE ANTENNA 4" × 4" LOW TEMP (3 REQ'D)

AREA = 16 IN^2 PERIMETER = 16 IN.

ITEM	CALCULATION	WEIGHT
PLATE	.030 × (400-16)	11.52
CHANNEL	.020 × 4. × 2	.16
ANGLE		1.13
ENCLOSURE	.028 × 16	.45
FRAME	.061 × 16	.98
SPACERS		.07
INSULATION	.004 × 16	.06
SHINGLE	-(1.39 × 400/144)	-3.86
STRUCTURAL PENALTY		(10.51)
WINDOW	3.97 × 16/144	(.44)
TOTAL ASSEMBLY		(10.95)
TOTAL GS ANTENNAS		32.85

ANTENNA WINDOWS AND MOUNTING

VOR ANTENNA 20" × 20" LOW TEMP (4 REQ'D)
AREA = 400 IN² PERIMETER = 80 IN.

ITEM	CALCULATION	WEIGHT
PLATE	.030 × (400-400)	.00
CHANNEL	.020 × 20 × 2	.80
ANGLE		1.13
ENCLOSURE	.028 × 80	2.24
FRAME	.061 × 80	4.88
SPACERS		.07
INSULATION	.004 × 80	.32
SHINGLE	-(1.39 × 400/144)	-3.86
STRUCTURAL PENALTY		(5 58)
WINDOW	3.97 × 400/144	(11.03)
TOTAL ASSEMBLY		(16.61)
TOTAL VOR ANTENNAS		66 44

RADAR ALTIMETER ANTENNA 5"×5" HIGH TEMP (6 REQ'D)
AREA = 25 IN² PERIMETER = 20 IN

ITEM	CALCULATION	WEIGHT
PLATE	.030 × (400-25)	11.25
CHANNEL	.020 × 5. × 2	.20
ANGLE		1.13
ENCLOSURE	.045 × 20.	.90
FRAME	.061 × 20.	1.22
SPACERS		.23
INSULATION	.004 × 20.	.08
SHINGLE	-(1.62 × 400/144)	-4.50
STRUCTURAL PENALTY		(10.51)
WINDOW	7.93 × 25/144	(1.38)
TOTAL ASSEMBLY		(11.89)
TOTAL RADAR ALT ANTENNAS		71 34

2.13 AVIONICS - WEIGHT SUMMARY

	QTY	UNITS	DIGITAL I/F UTS	CIRC.	COOLING	ANTENNAS	INSTAL.	TOTAL
Guidance & Navigation		(292)	(N/A)	(62)	(N/A)	(N/A)	(162)	516
IMU	4	140						
Star Tracker	3	120						
Horiz. Sensor	4	32						
Navigation Base							80	
Mounting Struct.							19	
Eq. Bay Struct.							63	
Circuitry				62				
Cold Plates/Rails		See Sect 2.14 Env. Control						
Flight Control		(224)	(N/A)	(44)	(N/A)	(N/A)	(59)	327
Thruster Elect.-ACPS	6	42	*					
Thruster El. ACPS/OMS	2	26	*					
Actuator Elect.	4	114	*					
Rate Gyro Pkg.	4	16						
Tot. Temp & Press Snsr	4	10						
Accelerometer	4	6						
Static Press Sensor	4	10						
			*Note: Ea. Elect. Unit Contains (1 DIU @ approx. 1# ea.					
Mounting Struct.							14	
Eq. Bay Struct.							45	
Circuitry				44				
Cold Plates/Rails		See Sect. 2.14 Env. Control						
Data Management		(530)	(296)	(238)	(N/A)	(N/A)	(138)	1202
Central Computer	4	340						
System Control Unit	1	7						
Mass Memory Mech.	2	20						
Mass Memory Elect.	2	12						
Area DIU's	24		139					
Crew Station DIU's	24		137					
IMU DIU's	4		20					
Data Bus		27						
Maintenance Recorder	2	100						
Input/Output Cntl Unit	4	24						
Mounting Struct.							32	
Eq. Bay Struct.							106	
Circuitry				238				
Cold Plates/Rails		See Sect. 2.14 Env. Control						
Subtotals This Pg.		1046	296	344	(N/A)	(N/A)	359	2045

2.13 Avionics Weight Summary - Cont.

	QTY	UNITS	DIGITAL I/F UTS	CIRC.	COOLING	ANTENNAS	INSTAL.	TOTAL
Communications & Navaids		(394)	(N/A)	(117)	(N/A)	(83)	(335)	929
S-Band Equip.	3	102				9		
Audio Control(Enter)	3	36						
Remote Intercom	1	7						
UHF Transceiver	2	24				26	30	
DME Receiver	3	90				*(4) 4	50	
Glideslope Receiver	3	12				6	32	
VOR/LOC Receiver	3	60				*(4) 32	66	
Radio Altimeter	3	63				*(6) 6	71	
Mounting Struct.							20	
Eq. Bay Struct.							66	
Circuitry				117				
Cold Plates/Rails		See Sect. 2.14 Env. Control						
Config. Seq		See Data Management Line Item No. 37 Previous Page						
Instrumentation		" "		"	" "	" "	"	"
Displays & Controls		(694)	(N/A)	(191)	(N/A)	(N/A)	(130)	1015
Center Front Panel	1	107						
Command Pilot Panel	1	131						
Pilot Panel	1	128						
Cmd Pilot OBD Panel	1	29						
Pilot OBD Panel	1	21						
Center Console Panel	1	145						
Floor Area	2	90						
Overhead Panels	1	30						
Docking Station	1	13						
Mounting Struct.							29	
Window Frame Mount							6	
Cockpit Panels							95	
Circuitry				191				
Cold Plates/Rails		See Sect. 2.14 Env. Control						
Equip. Bay Insulation		See Sect. 2.14 Env. Control						
Subtotals this page		1088	(N/A)	308	(N/A)	83	465	1944
Subtotals previous page		1046	296	344	(N/A)	(N/A)	359	2045
Totals		(2134)	(296)	(652)	(N/A)	(83)	(824)	(3989)
Contingency (15%)								599
Total - Avionics								4588

* No's in ( ) indicate Qty if different from that shown in Qty Column.

2.13 AVIONICS

LIST OF REFERENCES & DATA SOURCES

1. PG'S 2.13-5 & -6 BLOCK DIAGRAM & FUNCTIONS CHART; GUIDANCE & NAVIGATION ITEM (1).
2. FOUR RESPONSES (SINGER-KEARFOTT DIV., DELCO ELECT, HONEYWELL, LITTON/GUIDANCE & CONTROL DIV.) TO INERTIAL MEASUREMENT RFTI NO. 008.
3. FIVE RESPONSES (ITT AEROSPACE/OPTICAL DIV., KOLLSMAN INSTRUMENT, NORTHROP CORP., QUANTIC INDUSTRIES, TRW, INC) TO GIMBALLED STAR TRACKER RFTI NO. 043.
4. THREE RESPONSES (BARNES ENGINEERING, TRW SYSTEMS, QUANTIC INDUSTRIES, INC.) TO EARTH HORIZON SENSOR RFTI NO. 010.
5. NAVIGATION BASE ESTIMATED ASSUMING SIMILARITY TO APOLLO EQUIPMENT.
6. PG'S 2.13-5 & -6 BLOCK DIAGRAM & FUNCTIONS CHART; FLIGHT CONTROL SYSTEM ITEM (2).
7. FOUR RESPONSES (SPERRY RAND, LEAR SEIGLER INC., HONEYWELL INC., NORTHROP CORP.) TO THRUSTER ELECTRONICS RFTI NO. 026-9 FWD & -19 AFT.
8. FIVE RESPONSES (BENDIX CORP., SPERRY RAND CORP., LEAR SIEGLER INC., HONEYWELL INC., NORTHROP CORP.) TO TVC ELECTRONICS RFTI NO. 029.
9. FOUR RESPONSES (BENDIX, SPERRY RAND, HONEYWELL, NORTHROP CORP) TO RATE GYRO RFTI NO. 030.
10. TWO RESPONSES (SPERRY, KOLLSMAN) TO TOTAL PRESSURE AND TEMPERATURE SENSOR RFTI NO. 031.
11. FOUR RESPONSES (SYSTRON DONNER, HONEYWELL, BENDIX, NORTHROP CORP) TO TWO-AXIS ACCELEROMETER PACKAGE RFTI NO. 035.
12. TWO RESPONSES (SPERRY, KOLLSMAN) TO STATIC PRESSURE SENSOR RFTI NO. 032.

2.13 AVIONICS

LIST OF REFERENCES & DATA SOURCES - CON'T

13. PG'S 2.13-5 & -6 BLOCK DIAGRAM & FUNCTIONS CHART; DATA MANAGEMENT ITEM (3).
14. EIGHT RESPONSES (HUGHES AIRCRAFT, IBM, CONTROL DATA, DELCO ELECTRONICS, RAYTHEON, RCA, SINGER KEARFOTT, SPERRY-UNIVAC) TO DMS COMPUTER RFTI NO. 011. THE CENTRAL COMPUTER UNIT IS SIMILAR TO THE F-15 COMPUTER WITH ENLARGED STORAGE CAPABILITY (65K) & MODIFIED FOR 120VDC POWER AND LIQUID COOLING.
15. SEVEN RESPONSES (SAME AS 14 ABOVE EXCEPT WITHOUT SPERRY-UNIVAC) TO DMS SYSTEM CONTROL UNIT RFTI NO. 012.
16. EIGHT RESPONSES (SAME AS 14 ABOVE) TO DMS INPUT/OUTPUT CONTROL UNIT RFTI NO. 013.
17. NINE RESPONSES (SAME AS 14 ABOVE EXCEPT WITHOUT IBM AND IN ADDITION BENDIX, SCI ELECTRONICS) TO DMS DIGITAL INTERFACE UNIT (DIU) RFTI NO. 015. ALSO: THE DIU WEIGHTS ARE VERIFIED BY F-15 DATA.
18. ONE RESPONSE (HUGHES AIRCRAFT) TO DMS MASS STORAGE RFTI NO. 014. ALSO: MASS MEMORY UNIT WEIGHT IS VERIFIED BY GEMINI AND DC-10 HARDWARE DATA.
19. THREE RESPONSES (LEACH CONTROLS, LOCKHEED ELECTRONICS, ODETICS, INC) TO MAINTENANCE RECORDER RFTI NO. 016. ALSO: MAINTENANCE RECORDER WEIGHT IS VERIFIED BY APOLLO AND DC-10 HARDWARE DATA.
20. PG'S 2.13-5 & -6 BLOCK DIAGRAM & FUNCTIONS CHART; COMMUNICATIONS & NAVAIDS ITEM (4).
21. THREE RESPONSES (COLLINS RADIO, TRW, INC., PHILCO-FORD-WDL DIV) TO S-BAND & RANGING EQUIPMENT RFTI NO. 022. ALSO: NASA DATA ON UNIFIED S-BAND EQUIPMENT & AIRFORCE SPACE GROUND LINK SYSTEM.

2.13. AVIONICS

LIST OF REFERENCES & DATA SOURCES - CON'T

22. ONE RESPONSE (COLLINS RADIO) TO AUDIO CONTROL CENTER RFTI NO. 025. ALSO: WEIGHT IS VERIFIED BY APOLLO HARDWARE DATA.
23. REMOTE INTERCOM WEIGHT COMES FROM SKYLAB HARDWARE DATA.
24. FOUR RESPONSES (COLLINS RADIO, ECI, RCA, KING RADIO) TO UHF TRANSCEIVER RFTI NO. 024. TYPICAL WEIGHT FROM COLLINS PART NO. 719E-1 OR MAGNAVOX PART NO. 713CA.
25. THREE RESPONSES (LITTON-AMECOM DIV., TRANSCO PRODUCTS, ELECTRONIC RESOURCES) TO HIGH TEMPERATURE ANTENNAS RFTI NO. 041.
26. THREE RESPONSES (COLLINS RADIO, RCA ELECTROMAGNETIC & AVIATION, KING RADIO) TO DISTANCE MEASURING EQUIPMENT RFTI NO. 036. TYPICAL WEIGHT FROM COLLINS PART NO. 860E-3 OR KING RADIO PART NO. KDM 7000.
* 27. TWO RESPONSES (BENDIX, AVIONICS DIV, COLLINS RADIO) TO ILS RECEIVER RFTI NO. 037. TYPICAL WEIGHT FROM COLLINS PART NO. ILS-70 OR BENDIX PART NO. RIA-32A.
* 28. THREE RESPONSES (BENDIX, AVIONICS DIV., COLLINS RADIO, RAYTHEON EQUIP. DIV.) TO VOR RECEIVER RFTI NO. 023. TYPICAL WEIGHT FROM COLLINS PART NO. 51RV-2B OR BENDIX PART NO. RVA-33A.
29. TWO RESPONSES (BENDIX, AVIONICS DIV, COLLINS RADIO) TO RADIO ALTIMETER RFTI NO. 038. TYPICAL WEIGHT FROM COLLINS PART NO. AL-101 OR BENDIX PART NO. ALA-51A.

* RECENT SYSTEM CHANGES SHOW GLIDE SLOPE RCVR AND VOR/LOC RCVR VS ORIG. ILS AND VOR; EQUIP. IS VIRTUALLY COMPARABLE, NET WT. CHANGE IS +3#/UNIT OR +9# TOTAL.

2.13. AVIONICS

LIST OF REFERENCES & DATA SOURCES – CON'T

30. DISPLAYS & CONTROLS
   a. GENERAL – SEE ITEM (5) PG'S 2.13-5, -6 & 2.13-14, -15 & -19
   b. RPT NO. PR1057, TECHNICAL INFORMATION FOR SPACE SHUTTLE VIDEO DISPLAY SYSTEM, DATED 21 APRIL 1971, PREPARED BY NORDEN DIVISION OF UNITED AIRCRAFT CORP. NORWALK, CONNECTICUT. (DETAIL RPT CONTAINS 17 SECTIONS, APPROX. 130 PG'S PLUS SIX APPENDICES)
   c. DETAIL WEIGHT TABULATION OF CATHODE RAY TUBE INDICATOR UNIT IS SHOWN ON PAGE 3-14 OF RPT. PR1057. TOTAL WEIGHT IS 30.63 LB. WHICH IS BROKEN INTO 24 SEPARATE ITEMS QUOTED TO X.XX. THIS DATA IS CONSIDERED PROPRIETARY AND THEREFORE CANNOT BE REPRODUCED HERE.
   d. DETAIL WEIGHT TABULATION OF MULTIFUNCTION SYMBOL GENERATOR UNIT IS SHOWN ON PAGE 4-28 OF RPT. PR1057. TOTAL WEIGHT IS 29.89 LB WHICH IS BROKEN INTO 11 SEPARATE COMPONENTS PLUS 12 LOGIC MODULES QUOTED TO X.XX. THIS DATA IS CONSIDERED PROPRIETARY AND THEREFORE CANNOT BE REPRODUCED HERE.
   e. QUESTIONS RELATING TO ITEMS b, c, d, f CAN BE DIRECTED TO: MR. C.J. RICHARDSON
      NORDEN VIDEO SYSTEMS
      SENIOR SALES ENGINEER
      PHONE: 203-838-4471, EXT. 4685
   f. THE CAMERA READER MICROVIEWER WEIGHT IS ALSO BASED ON DATA CONTAINED IN RPT PR1057.
   g. IN ADDITION TO NORDEN, THERE HAVE BEEN NINE OTHER RESPONSES (ASTRONAUTICS CORP. OF AMER, BENDIX NAV & CNTL DIV, COLLINS, GE AVIONICS, KAISER AEROSPACE ELEC. CORP, LORAL, RAYTHEON, SPERRY RAND, WESTINGHOUSE) TO VIDEO DISPLAYS RFTI NO. 017.

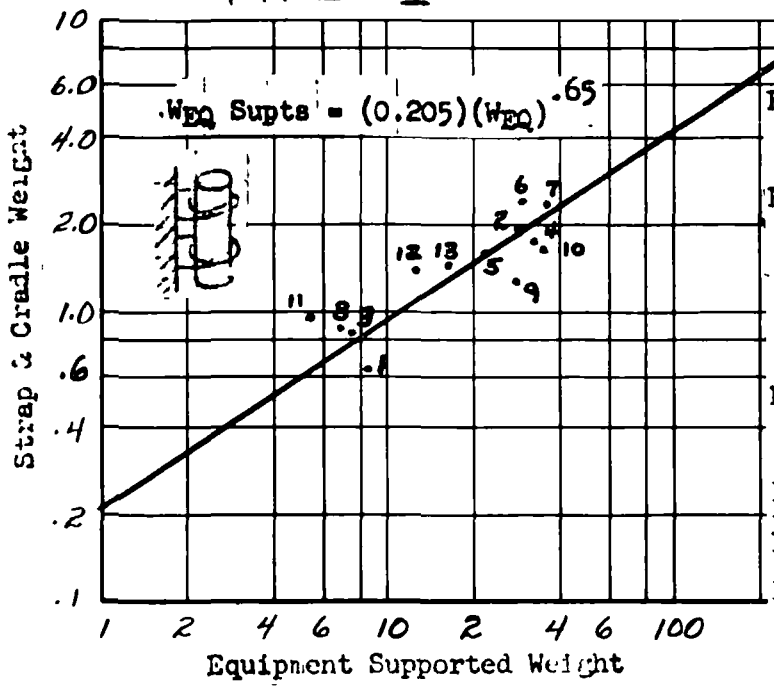
2.13. AVIONICS

LIST OF REFERENCES & DATA SOURCES – CON'T

30. DISPLAYS & CONTROLS – CON'T
   h. ATTITUDE DISPLAY INDICATOR WEIGHT IS BASED ON APOLLO CSM/LEM HARDWARE DATA.
   i. VERTICAL SCALE INDICATOR (VSI) WEIGHTS ARE BASED ON (SCALE) GEMINI/APOLLO HARDWARE & (TAPE) F-15 HARDWARE.
   j. FLIGHT GROUP DIALS, TIME REFERENCE SYS., ETC. IS BASED ON GENERAL AIRCRAFT/SPACECRAFT DEVICES.
   k. SWITCHES, TWIST KNOBS, ETC ARE GENERAL AIRCRAFT, SPACECRAFT EQUIP.
   l. CENTER STICK/RUDDER PEDALS ARE BASED ON F-15 WEIGHT DATA.
   m. ROTATIONAL & TRANSLATIONAL HAND CONTROLLER WEIGHTS ARE BASED ON APOLLO CSM HARDWARE DATA.

EQUIPMENT MOUNTING STRUCTURE

TYPE #1

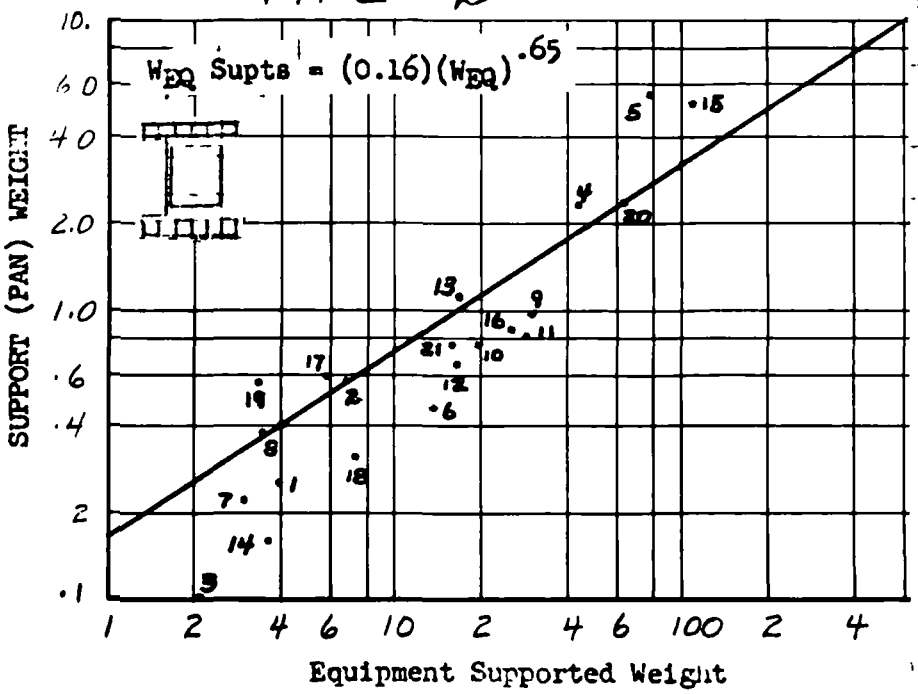


F-101A
1. Hyd. Accumulator
2. Hyd. Reservoir-Utility

F-101B
3. Emerg Brake-Air 100 In^3
4. Emerg Start-Air 3500 PSI
5. Hyd. Reservoir-Primary
6. Hyd. Reservoir-Utility
7. Eng Start-Air 3000 PSI

F4H-1
8. L.G. Emerg Air 100 in^3
9. Hyd. Pwr Control Reservoir
10. Hyd. Utility Reservoir
11. Emerg. Brake-Air 100 in^3
12. Emerg. Flap-Air 300 in^3
13. Canopy & Nose Gear 400 in^3

TYPE #2

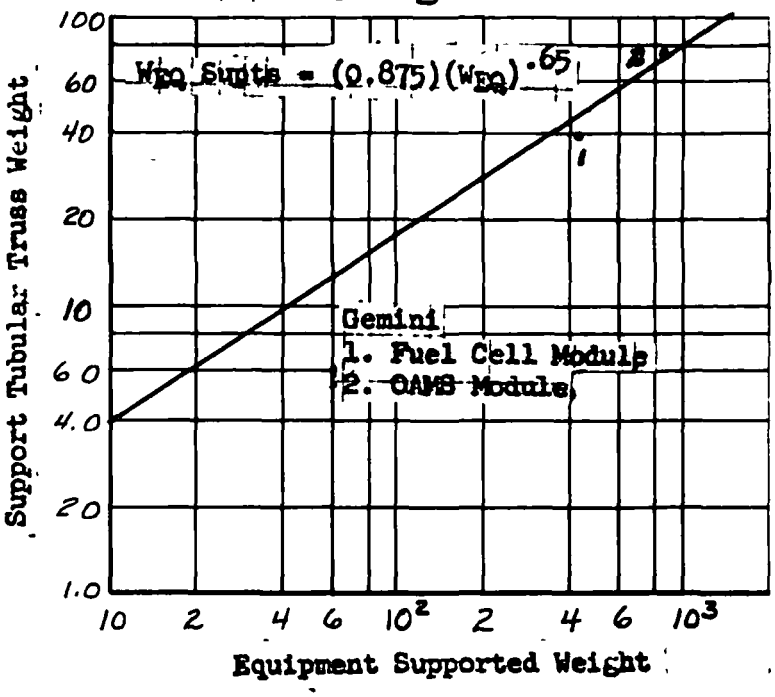


Mercury
1. Scanners
2. Attitude Gyro
3. Roll Rate Gyro
4. Auto H_2O
5. Retro Rockets
6. Tape Recorder
7. Water & Tank
8. Super Sarah
9. Survival Kit

Gemini
10. RCS Electronics
11. RCS Oxidizer & Tk
12. RCS Fuel & Tk
13. Batteries
14. Tele-Comm Gear
15. CO_2 Absorber
16. Re-entry O_2
17. Instrumentation
18. Whip Antenna
19. Recovery Gear
20. Roller
21. Water Tank

EQUIPMENT MOUNTING STRUCTURE - CON'T

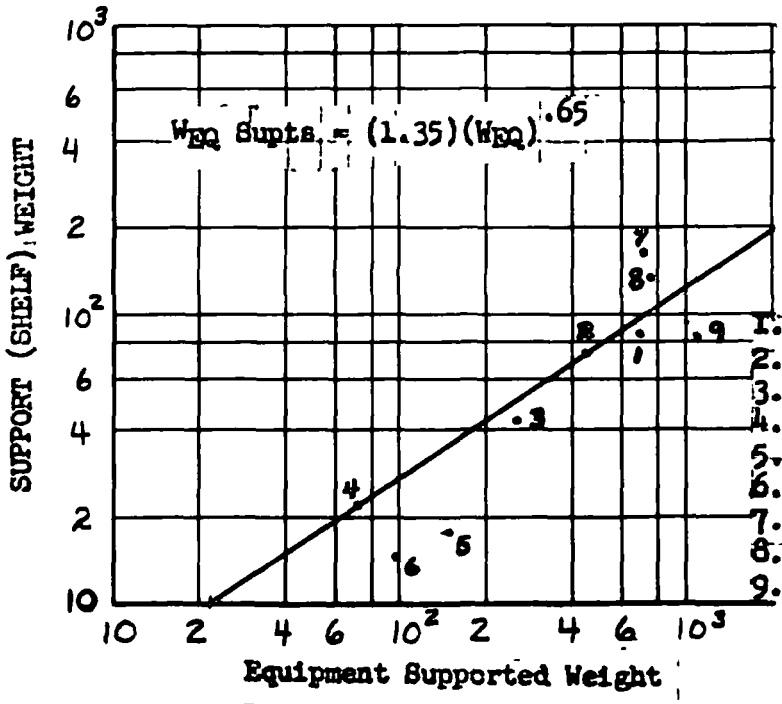
TYPE #3



A GENERAL METHOD OF ESTIMATING ALL TYPES OF EQUIPMENT LOCAL MOUNTING STR. IS USED FOR THE ORBITER SUBSYSTEMS, IT IS AN AVERAGE OF THE THREE TYPES OF MOUNTS SHOWN HERE. I.E.

$W_{EQ\ SUPTS} = .412(W_{EQ})^{.65}$

BASIC EQUIPMENT BAY STRUCTURE AND DISPLAY PANELS



1. Mercury Cabin
2. Gemini Cabin Wall
3. Gemini Retro-Beam
4. Gemini Elect Shelf-Adp.
5. Gemini ECS-Blast Shield
6. Gemini ECS-Box Mtg.
7. F-101B MG-13
8. F-101C Equip.
9. F4H-1 Equip.

2.14 Environmental Control [7849]

	Weight Coded Elsewhere		Page No.
Atmospheric Gas Storage and Supply		[166]	
Oxygen-Primary	(60)	N/A	2.14-35
Oxygen-Secondary	(17)	N/A	2.14-35
Dilutant Gas (Nitrogen)	(81)	N/A	2.14-35
Tankage			
O_2 - Primary	OAMS	N/A	
O_2 - Secondary		(21)	2.14-13
Dilutant - N_2		(100)	2.14-12
O_2 Delivery Equipment		(10)	2.14-13
N_2 Delivery Equipment		(8)	2.14-12
Mounting and Supports - O_2		(8)	2.14-13
Mounting and Supports - N_2		(19)	2.14-12
Gas Management/Processing		[685]	
Cabin Gas Control System CO_2/Odor Removal		(99)	2.14-15
Lithium Hydroxide Cartridges		(70)	2.14-17
Cannisters		(51)	2.14-17
Activated Charcoal	In Cartridge	N/A	
Fans		(76)	2.14-17
Humidity Control			
Condensing H-X		(31)	2.14-17
Window Defog H-X		(53)	2.14-17
Water Separators	[1](13)	N/A	
Cabin Temperature Control			
H-X		(50)	2.14-17
Fans	[2](76)	N/A	
Controls		(10)	2.14-17
Cabin Ventilation			
Fans	[2](76)	N/A	
Ducting		(203)	2.14-17

[1] See heat transport.
[2] See CO_2/Odor Removal.

2.14 Environmental Control - Cont.

	Weight Coded Elsewhere		Page No.
Gas Management/Processing - Cont.			
Atmosphere Pressure & Composition Control			
Insulation	See Insulation	N/A	
Mounting & Supports, Etc.		(42)	2.14-17
Heat Transport Subsystem		[2009]	
Cabin Circuit Coldplates (Dry)		(41)	2.14-20
Cabin Circuit Plumbing (Dry)		(6)	2.14-20
Cabin Circuit Reservoir (Dry)		(5)	2.14-20
Cabin Circuit Pump Package (Dry)		(30)	2.14-20
Condensate Water Subsys. (Dry)		(13)	2.14-20
Cabin Circuit Fluid	(96)	N/A	2.14-42
Interface H-X		(93)	2.14-20
Equipment Circuit Coldplates(Dry)		(139)	2.14-24
Temp. Control Panels (Dry)		(98)	2.14-24
Equipment Circuit Plumbing (Dry)		(65)	2.14-25
Equipment Circuit Pump Package(Dry)		(59)	2.14-24
Equipment Circuit Reservoir(Dry)		(24)	2.14-24
Equipment Circuit Fluid	(435)	N/A	
Radiator (Dry)			
Panels		(757)	2.14-49
Controls/Mechanisms		(440)	2.14-49
Ground Cooling H-X		(9)	2.14-24
Hydrogen Boiler/H-X		(96)	2.14-25
Water Boiler/Sublimator		N/A	
Insulation	See Insulation	N/A	
Valves and Controls		(55)	2.14-20&24
Mounting and Supports, Etc.		(79)	2.14-21&25
Water Management		[345]	
Water	(40)	N/A	
Tankage (Accumulators)		(77)	2.14-27
Pressurant System		N/A	
Plumbing/Controls		(37)	2.14-27
Insulation	See Insulation	N/A	
Mounting and Supports, Etc.		(22)	2.14-27
Waste Management Sys.		(192)	2.14-29
Mounting and Supports, Etc.		(17)	2.14-29

2.14 Environmental Control - Cont.

	Weight Coded Elsewhere	Page No.
Purge System & Fire Extinguish	[1119]	
Purge Liner	(677)	2.14-32
Supply & Discharge Headers	(426)	2.14-32
Fire Extinguishers	(16)	2.14-29
Insulation	[2877]	2.14-33
Cabin/Airlock	(286)	
Pwr/Cool. Transfer Tunnel	(855)	
N.L.G. Bay	(53)	
M.L.G. Bays	(519)	
Actuators		
Elevons	(163)	
Rudder	(63)	
Speedbrakes	(10)	
Fwd Equip Bay	(270)	
Aft Equip Bay	(25)	
N.L.G. Equip Bay	(182)	
Hydraulics Bay	(36)	
Cruise Engines	(415)	
Contingency	[648]	2.14-7

2.14 Environmental Control — 7849

Gas Supply System (Dry)	166
Gas Management, Processing (Dry)	685
Heat Transport System (inc. 1197 lbs. radiator) Dry	2009
Water Management System (Dry)	345
Purge System & Fire Extinguish	1119
Insulation	2877
Contingency	648

Dimensional and Design Criteria

Gas Requirements

Metabolic	1.84	lb/man-day
Leakage	3.5	lb/day
Repressurize	34.1	lb/repress. cycle (cabin) - 455 ft^3
Repressurize	28.6	lb/repress. cycle (airlock) - 260 ft^3 & ext. Tunnel - 121 ft^3
Cabin Volume	455	ft^3
Cabin Surface Area	405	ft^2, Airlock - 210 ft^2

Gas Supply	Source	Allocated Vol. ft^3	Storage Press. psi	Storage Temp. °F	F.S.	Tank Mtl.	No Tanks
Primary O_2	OAMS	N/A	N/A	N/A	N/A	N/A	N/A
Secondary O_2	ECLS	1.0	3000	70	2.0	Com-	1
Dilutant N_2	ECLS	5.5	3000	70	2.0	posite Fiber	2
Cooling H_2	OAMS	N/A	N/A	N/A	N/A	N/A	N/A

Coolant Load (BTU/Hr)	Launch Avg.	Launch Max.	On-Orbit Min.	On-Orbit Avg.	On-Orbit Max.	Entry Avg.	Entry Max.
Crew	466	550	434	466	550	466	550
ETC/LSS Equipment			2562	2562			3177
NON-ETC LSS Equip.			7339	10339			25609
Other			6570	10630			21634

Heat Transport

Cabin Coolant Flowrate	395 lb/hr
Equipment Coolant Flowrate	1645 & 3290 lb/hr
Radiator Area	615 ft^2

2.14 Environmental Control (Cont.)

Water Management	Nominal	Reserve
Drinking Water	6.3 lb/man-day*	28 man days
Wash/Waste	N/A lb/man-day*	N/A man days
Cooling	N/A lb/BTU*	N/A BTU

* 25 lb stored in cabin H_2O tank, additional H_2O requirement provided by fuel cell product water. Also, each fuel cell accumulator is filled at launch, i.e. 20 lb each = 40 lb H_2O, this quantity of water is provided for fuel cell cooling in the event of an abort.

Reference

A thorough evaluation of cooling and all other life support requirements has been made and is documented in MDAC Memo No. SSPI-E450-588.

2.14 Environmental Control

General - The Environmental Control and Life Support System (ECLS) consists of several interfacing subsystems as shown on page 2.14-9 and outlined below:

o Gas supply and control - provides a safe and controlled atmosphere for life support. Reference page 2.14-11 for schematic.

o Circulation, ventilation and contaminant control - interfaces with the atmosphere supply systems. Reference page 2.14-16 for schematic.

o Cabin thermal control - provides a safe and comfortable cabin environment. Interfaces with the gas supply and ventilation systems. Reference 2.14-19 for schematics.

o Equipment thermal control - provides adequate temperature control of equipments to insure reliable operation and service life. Equipment and cabin thermal control functions are interconnected by means of an interface heat exchanger, thereby allowing a balance and sharing of heat loads/ heat dissipation capability. Reference page 2.14-22 for schematic.

o Product water, fuel cell cooling and waste mangement is a fully integrated water management system. Adequate water and waste storage capability is provided so that dump modes can be delayed in the event of possible experiment/equipment contamination in the vicinity of the spacecraft. Reference page 2.14-26 for schematic.

o Ground purge system consists of a .004 titanium plenum chamber covering the total main propellant tank surface plus two inlet and two outlet delivery ducts running the full length of the tanks. Dry nitrogen is continually circulated thru this system from the ground launch support facility until lift-off. Reference page 2.14-31 for general arrangement.

o For crew safety two hand type fire extinguishers charged with 2.0 lbs CO_2 are located in the cabin. Reference page 2.14-30.

o In addition to the active systems discussed above a passive system is provided in the form of local insulation. Basic TPS insulation (Reference section 2.4) is provided to maintain a design structural limit of 300°F. The cabin and equipments, however, require lower design temperatures therefore, additional insulation is provided locally to protect the cabin and other regions where equipment is installed. Reference page 2.14-33 for analysis.

Basic system design satisfies the reliability requirement of FO, FS. Heat loads have been analyzed based on heat inputs of all significant sources, i.e. personnel, avionics, prime power, entry heating, on-orbit hot/cold cycle, etc. A mission profile has been established and therefore, the interactions of H.X.'s, radiator and passive inputs have been evaluated. Reference MDAC Memo No. SSPI-E450-588.

2.14 Environmental Control - Cont.

Methodology - An item-by-item weight analysis of the Environmental Control System has been performed and appears on the following pages. Every item shown on the schematic has been evaluated and keyed with a number appearing in the corresponding weight analysis table.

Major component weights are based on data obtained from detail analyses performed by Hamilton Standard. These data have been checked for validity by comparisons with existing hardware. All analyses performed by Hamilton Standard have been closely monitored by MDAC ECLS design specialists.

All other significant components are based on actual hardware data and detail references to part nos., project and/or vendor are included on the following pages. Basic sizing parameters have been established by using analytical methods. For example, cold plate weight is directly related to component power requirements, reference page 2.14-37.

General methods used for estimating mounting structure and circuitry are the same as those given in section 2.13. An analytical method is used to determine insulation requirements. This method is discussed on page 2.14-55.

Thorough weight evaluation coupled with detail technical design analysis lends credence to the system weight analysis shown here.

Fluids are calculated in detail in this section but are not coded in the dry weight summary given on pages 2.14-1 and -2. They are coded and listed in detail in Sections 2.23, 2.24 and 2.25.

Based on data shown in Section 1.0, 648 pounds is allowed for contingency.

INDEX

SHEET NO	SYSTEM DESCRIPTION	REMARKS
1	INDEX	
2	BLOCK DIAGRAM - E C L S SYSTEM	
3	CABIN AIR LOOP	
4	CABIN GAS SUPPLY AND CONTROL	
5	CABIN COOLANT LOOP	
6	EQUIPMENT COOLANT LOOP	
7	PRODUCT WATER SYSTEM	
8	WASTE MANAGEMENT - E C L S INTERFACE	
9	CRYOGENIC COOLING SYSTEM	
10	FIRE EXTINGUISHING SYSTEM	

REVISIONS			
LTR	DESCRIPTION	DATE	CHG
A	REMOVED PROVISIONS FOR N_2 COOLED AVIONICS ADDED FIRE EXT SYS DESCRIP SHTS 1, 2, 4, 6, & 10 EFFECTED	2 23-71	DWR
B	ADDED CONTROL & DISPLAY CALLOUTS, CHANGED CONDENSATE DUMP. SHEETS 1, 3, & 4-9 EFFECTED.	4 12 71	DWR

DR. D W RAY	2-10-71
CHK ECLS John Jazwa	5 MAR 71
STR	
GR	
APPD J L Mitchell	5 MAR 71
H. Kolp	5 MAR 71

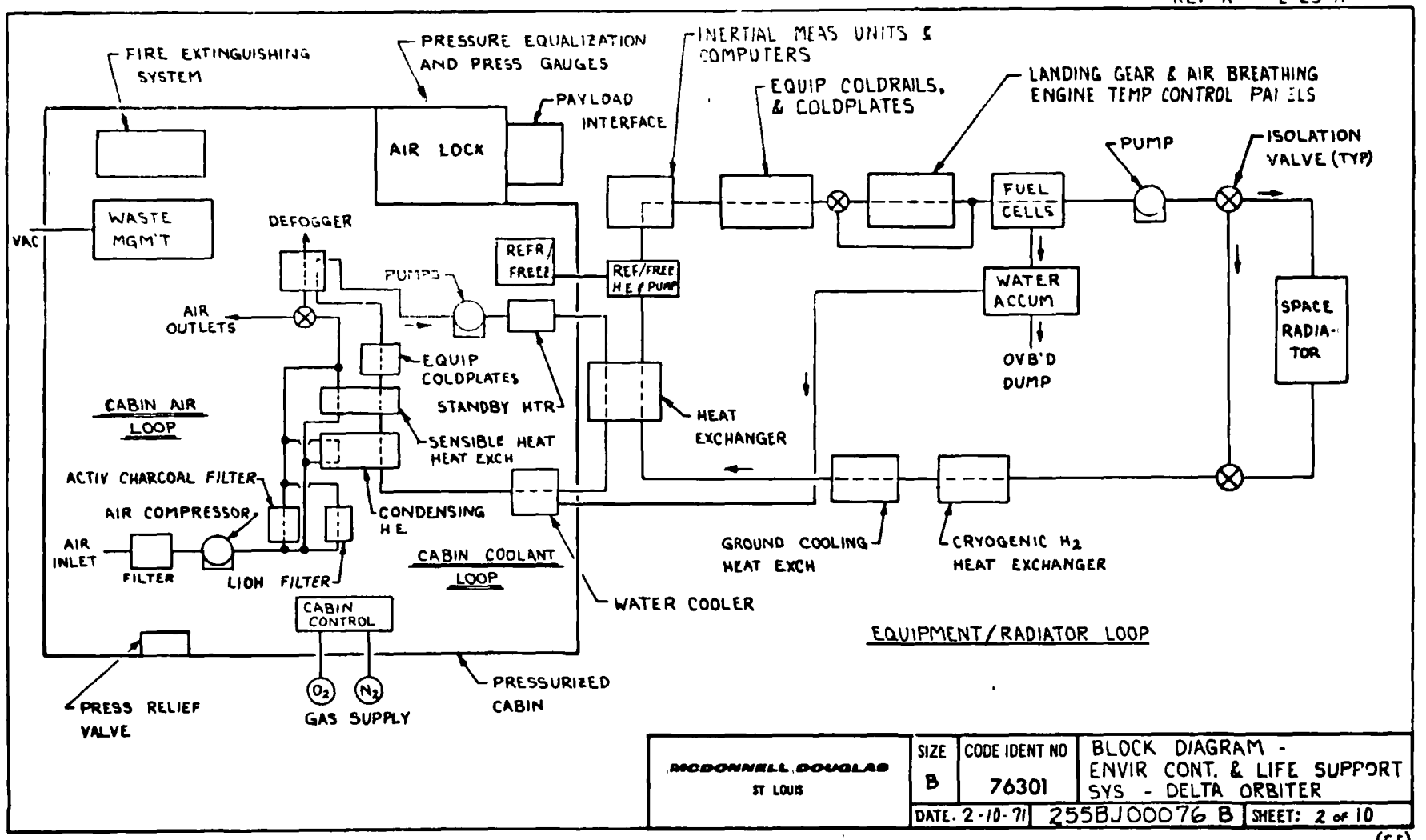
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
EASTERN DIVISION
SAINT LOUIS, MISSOURI
MCDONNELL DOUGLAS CORPORATION

SCHEMATIC DIAGRAM - ENVIR CONTROL & LIFE SUPPORT SYS - DELTA WING ORBITER

SIZE	CODE IDENT NO	
	76301	255BJ00076 B
SCALE	WT	LB SHEET: 1 OF 10

(U)

REV A 2-23-71



MCDONNELL DOUGLAS ST LOUIS	SIZE B	CODE IDENT NO 76301	BLOCK DIAGRAM - ENVIR CONT. & LIFE SUPPORT SYS - DELTA ORBITER
	DATE. 2-10-71	255BJ00076 B	SHEET: 2 of 10

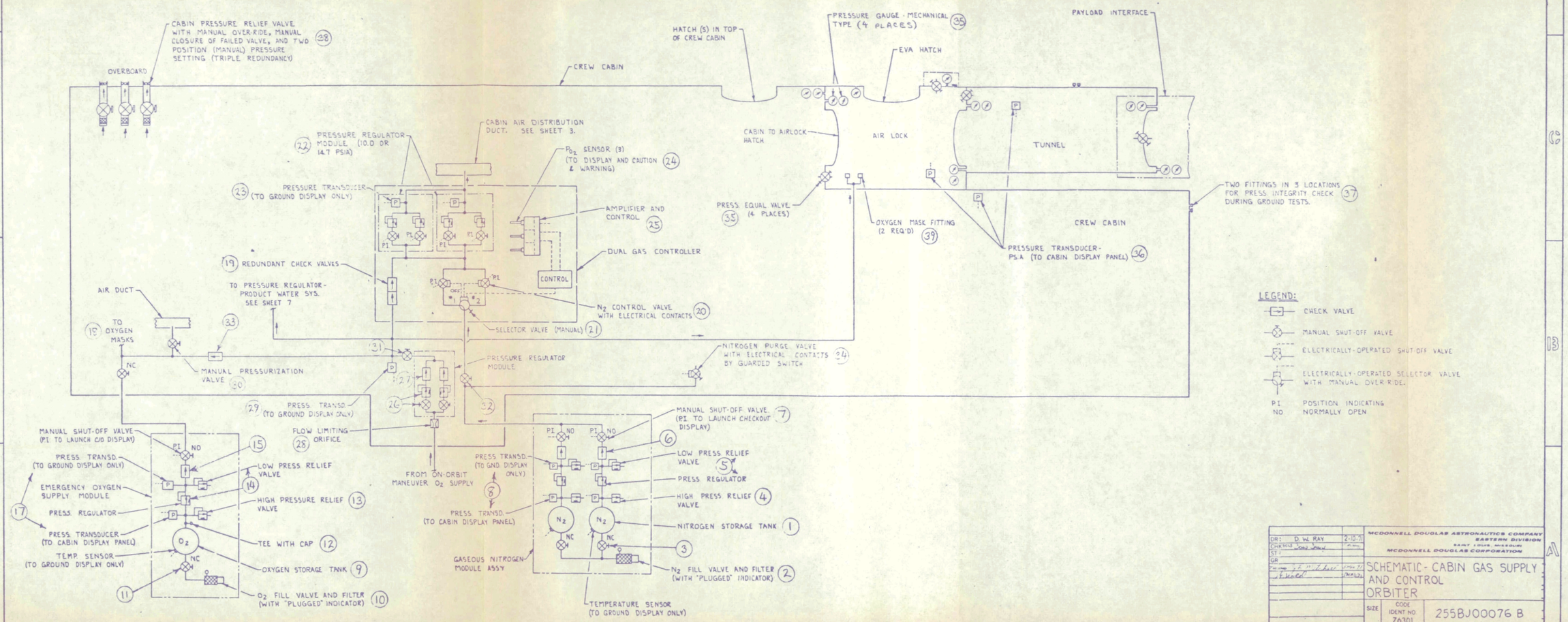
(U)

GROUP WEIGHT STATEMENT

2.14	ENVIRONMENTAL CONTROL	7849
	GAS SUPPLY SYSTEM (DRY)	166
	GAS MANAGEMENT, PROCESSING (DRY)	685
	HEAT TRANSPORT SYSTEM (DRY)	2009
	WATER MANAGEMENT SYSTEM (DRY)	345
	PURGE SYSTEM & FIRE EXTINGUISH	1119
	INSULATION	2877
	CONTINGENCY	648

WEIGHT SUMMARY

			PAGE NO.
GAS SUPPLY SYSTEM		(166)	
GASEOUS NITROGEN MODULE	127		2.14-12
EMERGENCY OXYGEN MODULE	39		2.14-13
GAS MANAGEMENT, PROCESSING		(685)	
CABIN GAS CONTROL SYSTEM	99		2.14-15
CABIN AIR LOOP	586		2.14-18
HEAT TRANSPORT SYSTEM		(2009)	
CABIN COOLANT LOOP	242		2.14-21
EQUIPMENT COOLANT LOOP	1767		2.14-25
WATER MANAGEMENT SYSTEM		(345)	
PRODUCT WATER SYSTEM	136		2.14-27
WASTE MANAGEMENT SYSTEM	209		2 14-29
PURGE SYSTEM & FIRE EXTINGUISH		(1119)	
FIRE EXTINGUISHERS	16		2.14-29
PURGE SYSTEM	1103		2.14-32
INSULATION		(2877)	2.14-33
CONTINGENCY		(648)	2.14-7
TOTAL DRY WEIGHT		7849	
FLUIDS SUMMARY		(1047)	2.14-34
INITIAL GAS	59		2.14-35
NITROGEN	81		2.14-35
OXYGEN	60		2.14-35
EMERGENCY OXYGEN	17		2.14-35
COOLING WATER	136		2.14-42
COOLING FREON	435		2.14-43
DRINKING WATER	25		2.14-42
COOLING CRYOGEN (H_2)	234		2.14-25



DR: D. W. RAY	2-10-71	McDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION SAINT LOUIS, MISSOURI A McDONNELL DOUGLAS CORPORATION
CHK'D:		
ST:		
GR:		
		SCHEMATIC - CABIN GAS SUPPLY AND CONTROL ORBITER
SIZE	CODE IDENT NO 76301	255BJ00076 B
SCALE	WT	LB SHEET: 4 OF 10

2.14-11

2.14 ENVIRONMENTAL CONTROL

WEIGHT SUBSTANTIATION

GAS SUPPLY SYSTEM - SEE PG. 2.14-11 FOR SCHEMATIC

ITEM	REF NO. PG. 2.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
GASEOUS NITROGEN MODULE				
(1) NITROGEN STORAGE TANK	1.	50.	2	100.
(2) N_2 FILL VALVE & FILTER	2.	0.25	1	0.25
(3) H.P. S/O VALVE	3.	1.25	2	2.50
(4) H.P. PRESSURE RELIEF VALVE	EST.	0.4	2	0.8
(5) REGULATOR & RELIEF VALVE	4.	0.75	2	1.5
(6) CHECK VALVE	5.	0.12	2	0.24
(7) MANUAL S/O VALVE	6.	0.3	2	0.6
(8) PRESSURE TRANSDUCER	EST.	0.6	4	2.4
SUBTOTAL EQUIPMENT				(108.29)
PLUMBING & FITTINGS	12.	2.0	2	4.0
CIRCUITRY & MISC.	13.	0.25	8	2.0
MOUNTING STR. $.412(108.29 + 81.4 \text{ LB } N_2)^{.65}$	14.			12.46
TOTAL NITROGEN MODULE				126.75 LB.

CONTAINS A TOTAL OF 81.4 LB. N_2 (SEE PAGE 2.14-35 FOR GAS REQUIREMENTS) AND IS INCLUDED IN THE INVENTORY OF FLUIDS SHOWN ON PAGE 2.14-34.

(ALSO SHOWN IN SECTIONS 2.23, 2.25 & 2.26

WEIGHT SUBSTANTIATION

GAS SUPPLY SYSTEM - CONT.

ITEM	REF NO. PG. 2.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
EMERGENCY OXYGEN MODULE				
(9) OXYGEN STORAGE TANK	7.	21.	1	21.
(10) O_2 FILL VALVE & FILTER	8.	0.25	1	0.25
(11) H.P. S/O VALVE	3.	1.25	1	1.25
(12) TEE WITH CAP	9.	0.12	1	0.12
(13) H.P. RELIEF VALVE	EST.	0.4	1	0.4
(14) REGULATOR & RELIEF VALVE	4.	0.75	1	0.75
(15) CHECK VALVE	5.	0.12	1	0.12
(16) MANUAL S/O VALVE	6.	0.3	1	0.3
(17) PRESSURE TRANSDUCER	EST.	0.6	2	1.2
(18) OXYGEN MASKS	10.	2.7	2	5.4
SUBTOTAL EQUIPMENT				(30.79
PLUMBING & FITTINGS	12.	2.0	1	2.0
CIRCUITRY & MISC.	13.	0.25	4	1.0
MOUNTING STR. $.412\,(30.79 + 17.2 \text{ LB } O_2)^{.65}$	14.			5.10
TOTAL EMERGENCY OXYGEN MODULE				38.89 LB.

CONTAINS A TOTAL OF 17.2 LB. O_2 (SEE PAGE 2.14-[illegible] FOR GAS REQUIREMENTS) AND IS INCLUDED IN THE INVENTORY OF FLUIDS SHOWN ON PAGE 2.14-34.

WEIGHT SUBSTANTIATION

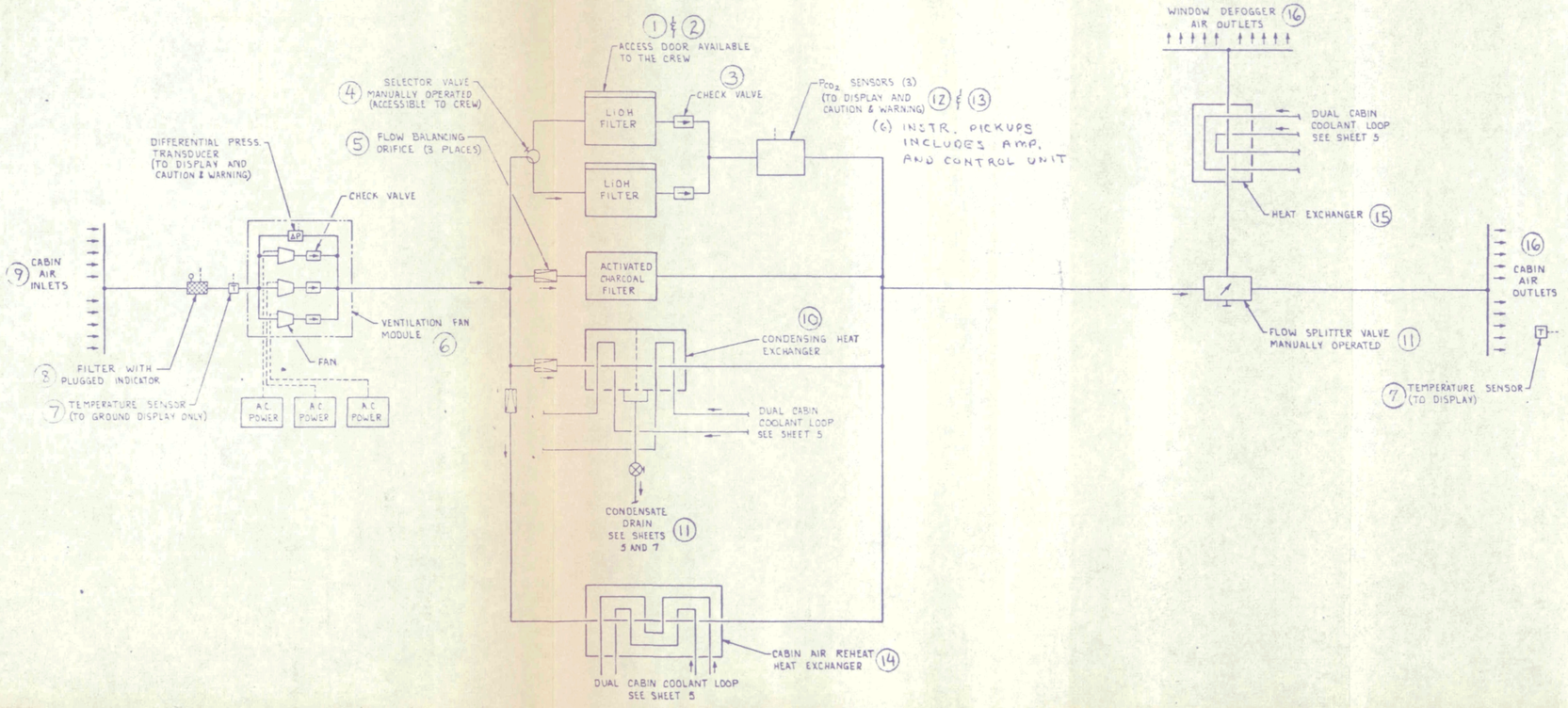
GAS MANAGEMENT, PROCESSING - SEE PG. 2.14-11 FOR SCHEMATIC

ITEM	REF. NO. PG. 2.14-60 TO 63	UNIT WEIGHT	QTY	TOTAL WEIGHT
CABIN GAS CONTROL SYSTEM				
DUAL GAS CONTROLLER				
(19) CHECK VALVE	5.	0.12	2	0.24
(20) NITROGEN CONTROL VALVE	11.	1.7	2	3.4
(21) SELECTOR VALVE	15.	2.5	1	2.5
(22) PRESSURE REG. MODULE	16.	8.0	2	16.0
(23) PRESSURE TRANSDUCER	EST.	0.6	2	1.2
(24) PO_2 SENSOR	17.	0.25	3	0.75
(25) AMPLIFIER & CONTROL	18.	1.5	3	4.5
PRESSURE REGULATOR MODULE				
(26) PRESSURE REG. MODULE	16.	8.0	1	8.0
(27) CHECK VALVE	5.	0.12	2	0.24
(28) FLOW LIMITING ORIFICE	EST.	0.01	1	0.01
(29) PRESSURE TRANSDUCER	EST.	0.6	1	0.6
(30) MANUAL PRESSURE VALVE-EMER. OXYGEN	6.	0.3	2	0.6
(31) OXYGEN MANUAL S/O VALVE	6.	0.3	1	0.3
(32) NITROGEN MANUAL S/O VALVE	6.	0.3	1	0.3
(33) CHECK VALVE- OXYGEN	5.	0.12	1	0.12
(34) NITROGEN PURGE VALVE	EST.	2.5	1	2.5
(35) PRESSURE EQUILIZATION VALVE & GAUGES ASSY	19.	6.2	4	24.8

WEIGHT SUBSTANTIATION

GAS MANAGEMENT, PROCESSING - CONT.

ITEM	REF NO. PG. 2.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
PRESSURE REGULATOR MODULE - CONT.				
(36) PRESSURE TRANSDUCER	EST.	0.6	3	1.8
(37) FITTINGS - PRESSURE INTEGRITY	EST.	0.1	6	0.6
(38) CABIN PRESSURE RELIEF VALVE	20.	4.2	3	12.6
(39) OXYGEN MASK FITTING	EST.	0.1	2	0.2
SUBTOTAL EQUIPMENT				(81.26)
PLUMBINGS & FITTINGS	21.	5.0	1	5.0
CIRCUITRY & MISC.	13.	0.25	23	5.75
MOUNTING STR. $.412(81.26)^{.65}$	14.			7.18
TOTAL CABIN GAS CONTROL SYSTEM				99.19 LB.



DR: D. W. RAY	2-10-71	McDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION, SAINT LOUIS, MISSOURI
CHK'RS		McDONNELL DOUGLAS CORPORATION
STR		
GR		SCHEMATIC - CABIN AIR LOOP - ORBITER
		SIZE: A1 · CODE IDENT NO. 76301 · 255BJ00076 B
		SCALE · WT · LB · SHEET: 3 OF 10

WEIGHT SUBSTANTIATION

CABIN AIR LOOP - SEE PAGE 2.14-16 FOR SCHEMATIC

ITEM		REF. NO. PG. 2.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
(1)	LITHIUM HYDROXIDE PKG.,	22.	50.8	1	50.8
(2)	LITHIUM HYDROXIDE CART. (2 MEN - 7 DAYS)	23.	15.5	*4.5	69.75
(3)	CHECK VALVE	5.	0.12	2	0.24
(4)	SELECTOR VALVE	15.	2.5	1	2.5
(5)	ORIFICE	EST.	0.01	3	0.03
(6)	VENTILATION FAN MOD.	24.	75.7	1	75.7
(7)	TEMPERATURE SENSOR	EST.	0.05	2	0.10
(8)	FILTER WITH PLUGGED IND.	EST.	0.5	1	0.5
(10)	CONDENSING H.X.	25.	31.0	1	31.0
(11)	CONTROL VALVE MANUAL	26.	1.25	2	2.50
(12)	PCO_2 SENSOR	27.	0.25	3	0.75
(13)	AMPLIFIER & CONTROL	18.	1.50	3	4.50
(14)	CABIN H.X.	28.	49.7	1	49.7
(15)	WINDOW DEFOGGER H.X.	29.	53.0	1	53.0
SUBTOTAL EQUIPMENT					(341.07)
(9)	CABIN AIR INLET DUCTS	30.	39.2	1	39.2
(16)	CABIN AIR OUTLET DUCTS	31.	163.5	1	163.5
	PLUMBINGS & FITTINGS	EST.			10.0
	POWER CIRC. $.039 (75.7)^{1.298}$ FANS	32.			10.72

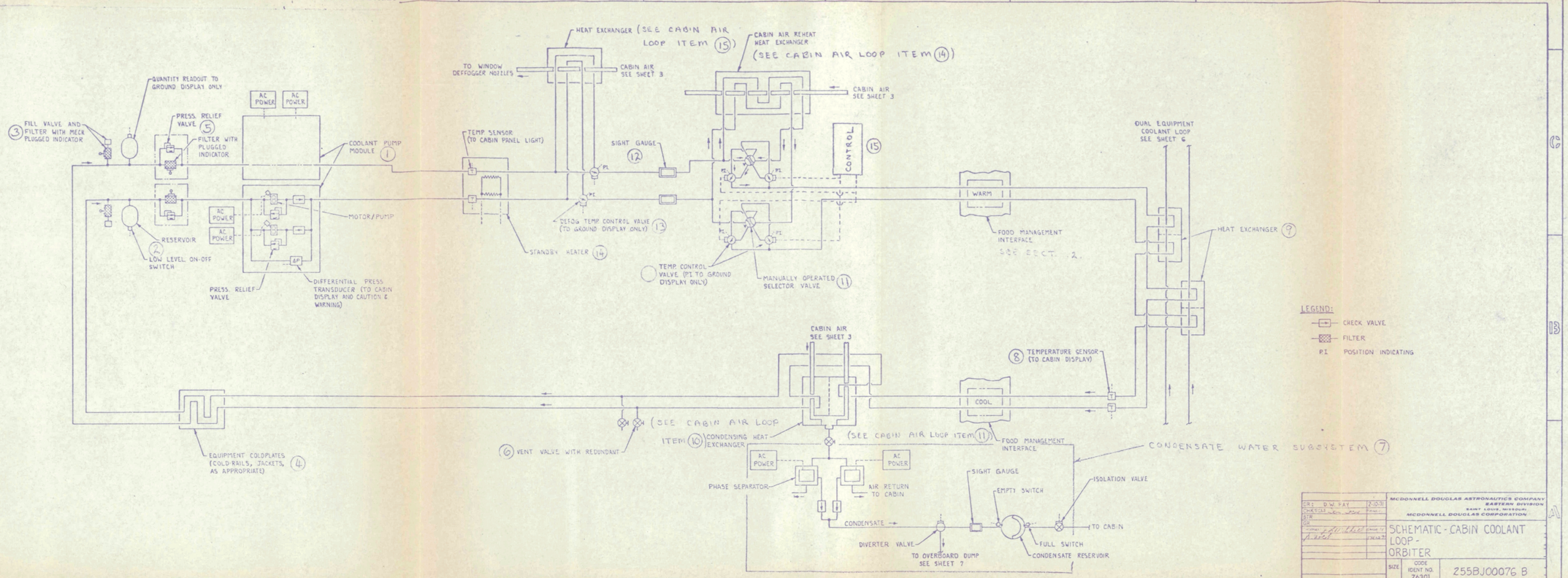
* 9 CARTRIDGES REQUIRED FOR 28 MAN-DAYS

WEIGHT SUBSTANTIATION

CABIN AIR LOOP - CONT.

ITEM	REF. NO. P6. 2.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
CIRCUITRY & MISC.	13.	0.25	10	2.5
MOUNTING STR. * $.412(341.07 + 16.60 \text{ LB } H_2O)^{.65}$	14.			18.82
TOTAL CABIN AIR LOOP				585.81 LB

* H_2O ADDED FOR CALCULATIONS ONLY - SEE PAGE 2.14-42



DR: D.W.RAY	2/10/71	MCDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION SAINT LOUIS, MISSOURI MCDONNELL DOUGLAS CORPORATION
CHK'D		
STR		
QUAL		
PROJ ENGR		SCHEMATIC - CABIN COOLANT LOOP - ORBITER
		SIZE: CODE IDENT NO. 76301 — 255BJ00076 B
		SCALE: WT: LB SHEET: 5 OF 10

WEIGHT SUBSTANTIATION

CABIN COOLANT LOOP - SEE PG. 2.14-19 FOR SCHEMATIC

ITEM		REF. NO. PG. 2.14-60 TO 63	UNIT WEIGHT	QTY	TOTAL WEIGHT
(1)	COOLANT PUMP PKG.	33.	15.0	2	30.0
(2)	RESERVOIR	34.	2.3	2	4.6
(3)	FILL VALVE & FILTER	EST.	0.25	2	0.5
(4)	CABIN & CREW STATION COLD PLATES	PG. 2.14-39	40.52	1	40.52
(5)	FILTER & RELIEF VALVE	35.	3.0	2	6.0
(6)	VENT VALVE	36.	0.4	2	0.8
(7)	CONDENSATE WATER SUBSYSTEM	37.	13.3	1	13.3
(8)	TEMPERATURE SENSOR	EST.	0.10	4	0.40
(9)	INTERFACE HEAT EXCHANGER	38.	46.4	2	92.8
(10)	TEMPERATURE CONTROL VALVE	11.	1.7	4	6.8
(11)	MANUAL SELECTOR VALVE	EST.	1.9	2	3.8
(12)	SIGHT GAUGE	EST.	0.10	2	0.20
(13)	DEFOG TEMPERATURE CONTROL VALVE	11.	1.7	2	3.4
(14)	STANDBY HEATER	EST.	5.0	1	5.0
(15)	AMPLIFIER & CONTROL	18.	1.5	1	1.5
SUBTOTAL EQUIPMENT					(209.62)
	PLUMBING & FITTINGS	39.			

$= \frac{5}{16}$ O.D. × 0.020 WALL ALUM × 200 FT × 1.30 FTGS.

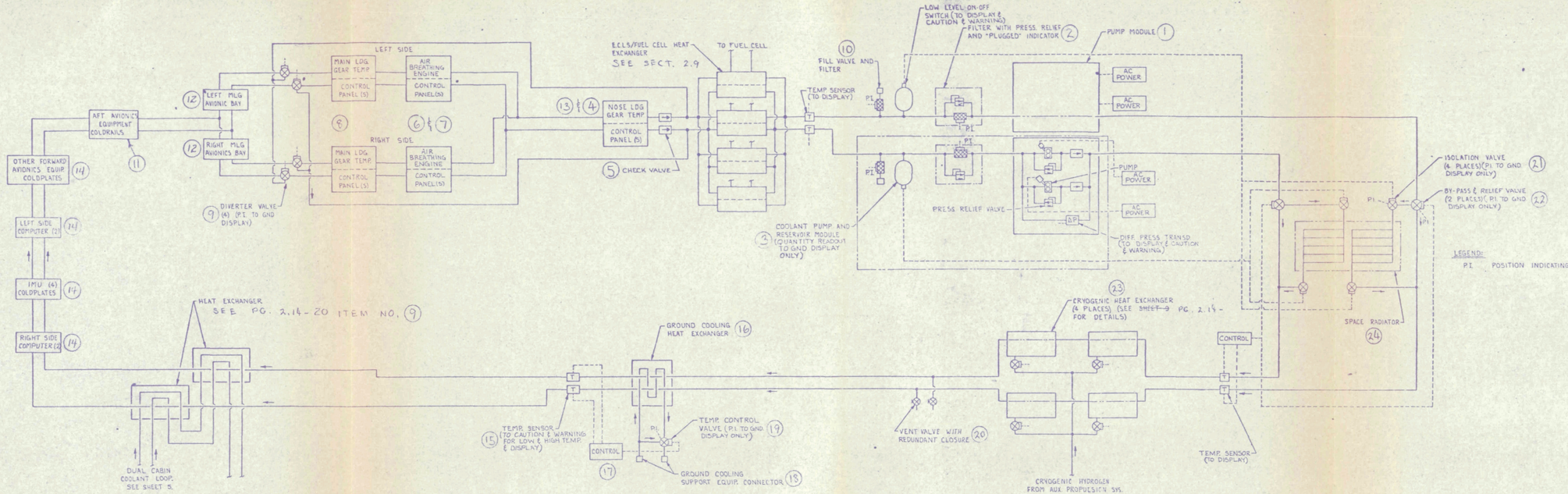
= 0.0018 LB/IN × 200 FT × 12 IN/FT × 1.30 = 5.62

WEIGHT SUBSTANTIATION

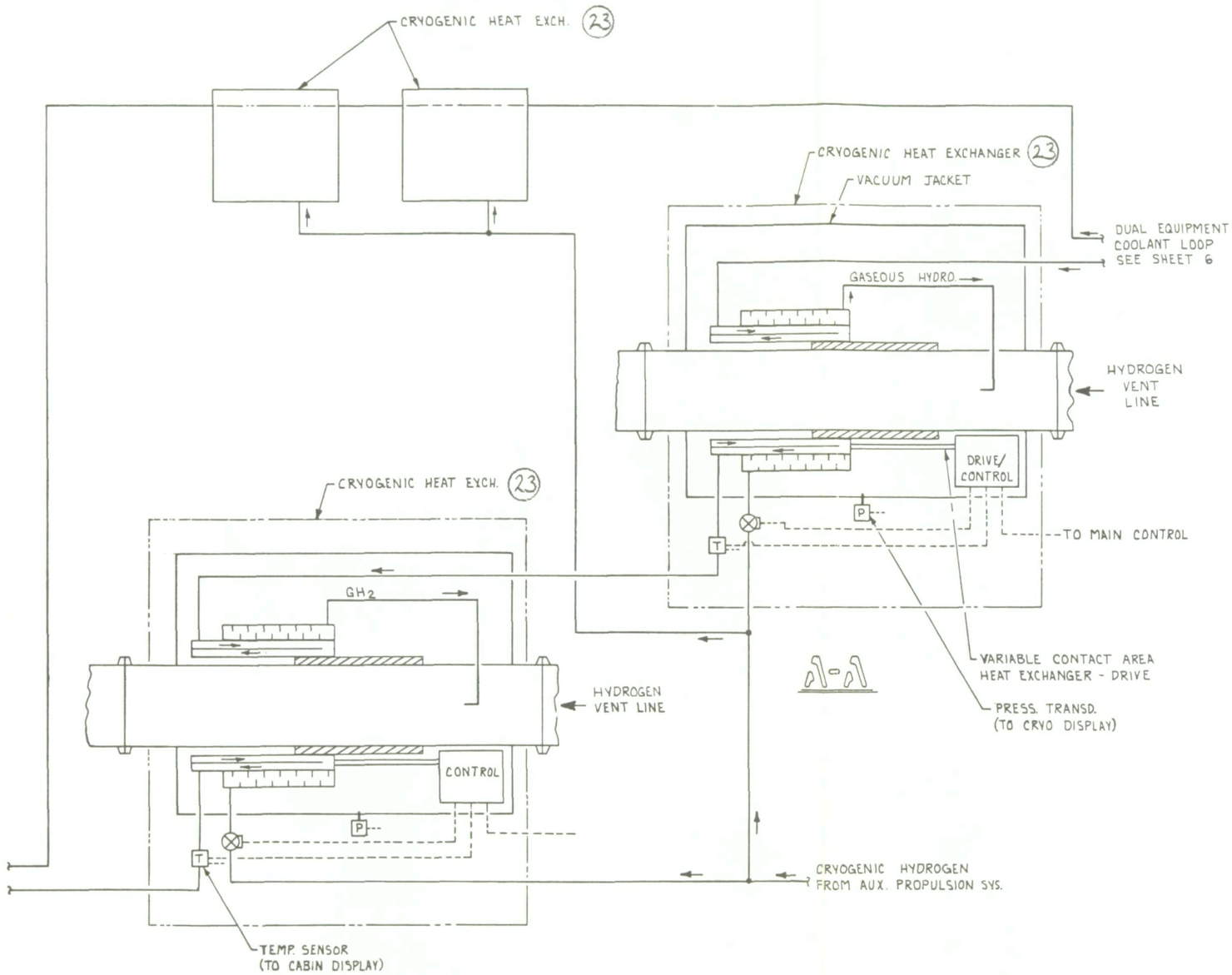
CABIN COOLANT LOOP - CONT.

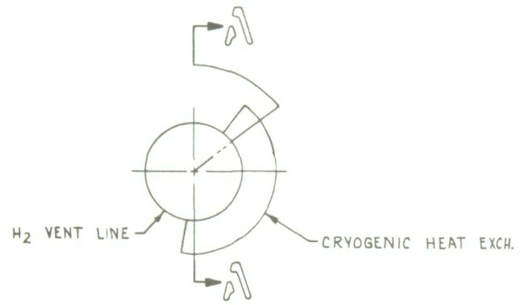
ITEM	REF. NO. PG. Z.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
POWER CIRCUIT $.039\ (30.0)^{1.298}$	32.			3.22
CIRCUITRY & MISC.	13.	0.25	29	7.25
MOUNTING STR. * $.412(209.62 + 74.50\ LB\ H_2O)^{.65}$	14.			16.21
TOTAL CABIN COOLANT LOOP				241.92 LB

* H_2O ADDED FOR CALCULATIONS ONLY - SEE PAGE 2.14-42



DR	D. W. RAY	2-10-71	MCDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION SAINT LOUIS, MISSOURI MCDONNELL DOUGLAS CORPORATION
CHECKED			
STR			
QA			
PROJ ENGR			SCHEMATIC - EQUIPMENT COOLANT LOOP - ORBITER - BASELINE
			SIZE: CODE IDENT NO. 76301 — 255BJ00076 B
			SCALE: WT: SHEET: 6 OF 10





DR: D. W. RAY	2-10-71	MCDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION SAINT LOUIS, MISSOURI MCDONNELL DOUGLAS CORPORATION
CHK		
STR		SCHEMATIC - CRYOGENIC COOLING SYSTEM
GR		
APPD		

SIZE	CODE IDENT NO.	
	76301	255BJ00076 B
SCALE	WT	LB SHEET: 9 OF 10

WEIGHT SUBSTANTIATION

EQUIPMENT COOLANT LOOP- SEE PAGE 2.14-22 FOR SCHEMATIC

ITEM		REF NO. PG 2.14-60 TO 63	UNIT WEIGHT	QTY	TOTAL WEIGHT
(1)	COOLANT PUMP PACKAGE	33.	29.5	2	59.0
(2)	FILTER & RELIEF VALVE	35.	3.0	2	6.0
(3)	RESERVOIR	34.	12.0	2	24.0
(4)	TEMPERATURE CONTROL PANEL N L G.	PG. 2.14-40	2.16	1	2.16
(5)	CHECK VALVE	EST.	0.15	2	0.30
(6)	TEMPERATURE CONTROL PANEL ABES - INLET	PG 2.14-40	16.3	4	65.2
(7)	TEMPERATURE CONTROL PANEL ABES - OUTLET	PG. 2.14-40	6 7	4	26.8
(8)	TEMPERATURE CONTROL PANEL M. L G.	PG. 2.14-40	2.16	2	4.32
(9)	DIVERTER VALVE	11.	1.7	2	3.4
(10)	FILL VALVE & FILTER	EST.	0.25	2	0.50
(11)	AFT EQ BAY COLD PLATES	PG. 2.14-39	21.24	1	21.24
(12)	M.L G. WELL EQ COLD PLATES	PG. 2.14-39	9.21	1	9.21
(13)	N L.G. WELL EQ COLD PLATES	PG. 2.14-39	5.53	1	5.53
(14)	FORWARD EQ. BAY COLD PLATES	PG. 2.14-39	103.28	1	103.28
(15)	TEMPERATURE SENSOR	EST.	0 10	6	0.60
(16)	GROUND COOLING H X.	41.	9.2	1	9.2
(17)	AMPLIFIER & CONTROL	18.	1.5	2	3.0
(18)	GSE CONNECTOR	EST	0.5	2	1.0

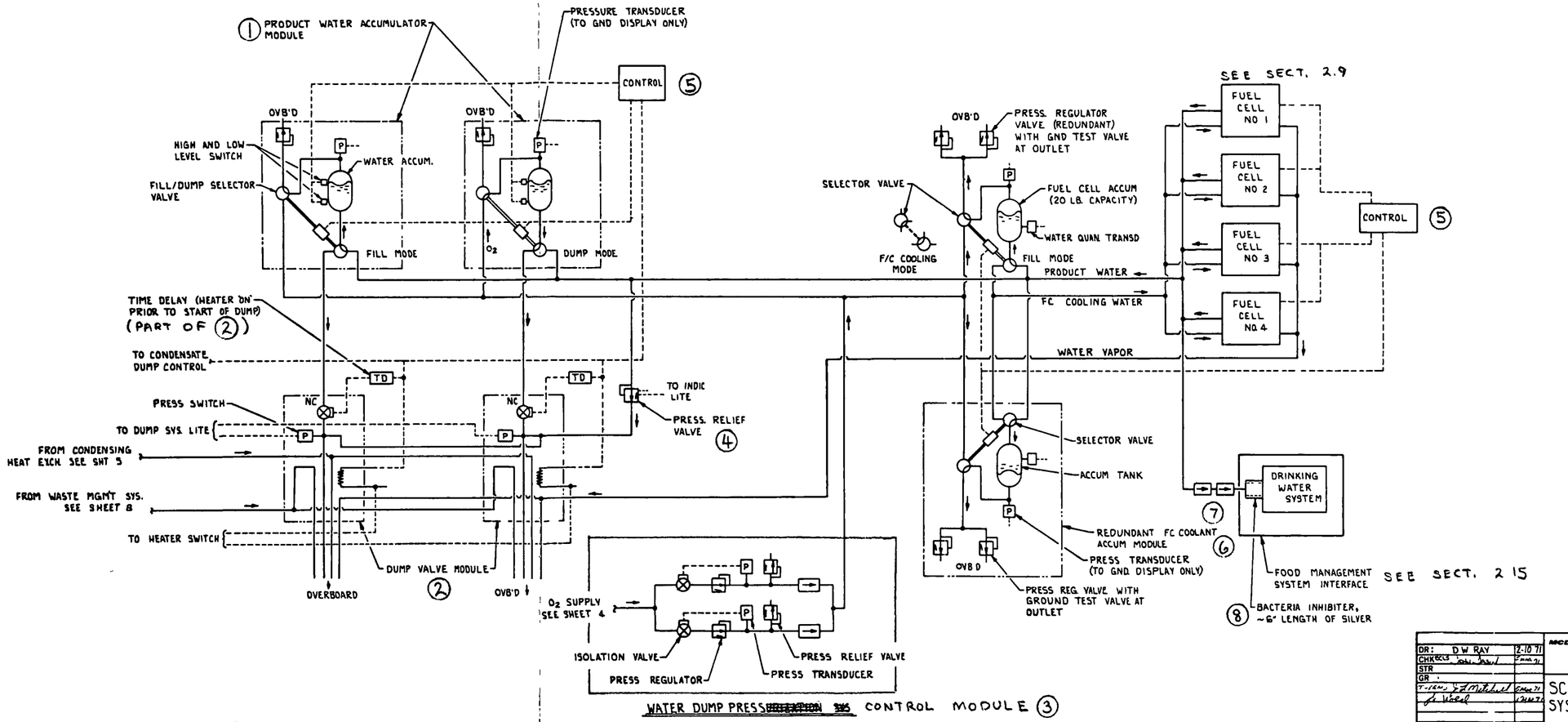
WEIGHT SUBSTANTIATION

EQUIPMENT COOLANT LOOP - CONT.

ITEM	REF. NO. PG 2.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
(19) TEMPERATURE CONTROL VALVE	11.	1.7	1	1 7
(20) VENT VALVE	6.	0.4	2	0.8
(21) ISOLATION VALVE	11.	1 7	4	6.8
(22) BY-PASS & RELIEF VALVE	11.	1 7	2	3 4
(23) CRYOGENIC HEAT EXCHANGER	42.	24.0	4	9C 0
SUBTOTAL EQUIPMENT				(452.44)
SPACE RADIATOR (615 FT² EFFECTIVE AREA)	PG 2.14-49 48.			1177.47
PLUMBING & FITTINGS	40.			
$= \frac{1}{2}$ O.D. × .0020 WALL ALUM. × 690 FT × FTGS 1.30				
= 690 FT × 2 × 0.0030 LB/IN × 12 IN/FT × 1.30 =				64.6
POWER CIRCUITRY 0.039 (59) TUMPS 1298	32.			7 76
CIRCUITRY & MISC.	13.	0.25	59	14.75
MOUNTING STR. * 0.412(45344 + 258.43)^.65	14.			29 44
TOTAL EQUIPMENT LOOP				1767.46 LB

NOTE: CRYOGENIC HYDROGEN IS USED IN THE CRYOGENIC HEAT EXCHANGERS AS A MAJOR HEAT DISSIPATION MODE OF THE SYSTEM. A THOUROUGH HEAT LOAD ANALYSIS HAS BEEN PERFORMED AND TOTAL HEAT TRANSPORT REQUIREMENTS HAVE BEEN ESTABLISHED (REF MDAC MEMO NO. SSPI-E450-53E). BASED ON THIS ANALYSIS; TOTAL CRYOGENIC HYDROGEN REQUIREMENT IS: 67×10^{-5} LB/BTU × 349.5×10^3 BTU = 234 LB H_2. THIS HYDROGEN IS INCLUDED IN SECT 2.2C IN FLIGHT LOSSES

* FREON ADDED FOR CALCULATIONS ONLY - SEE PAGE 2.14-43



DR: D W RAY	12-10 71	McDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION, SAINT LOUIS MISSOURI, McDONNELL DOUGLAS CORPORATION
CHK		SCHEMATIC - PRODUCT WATER SYSTEM - ORBITER
STR		
GR		
SIZE:	CODE IDENT NO 76301	255BJ00076 B
SCALE	WT	LB SHEET 7 OF 10

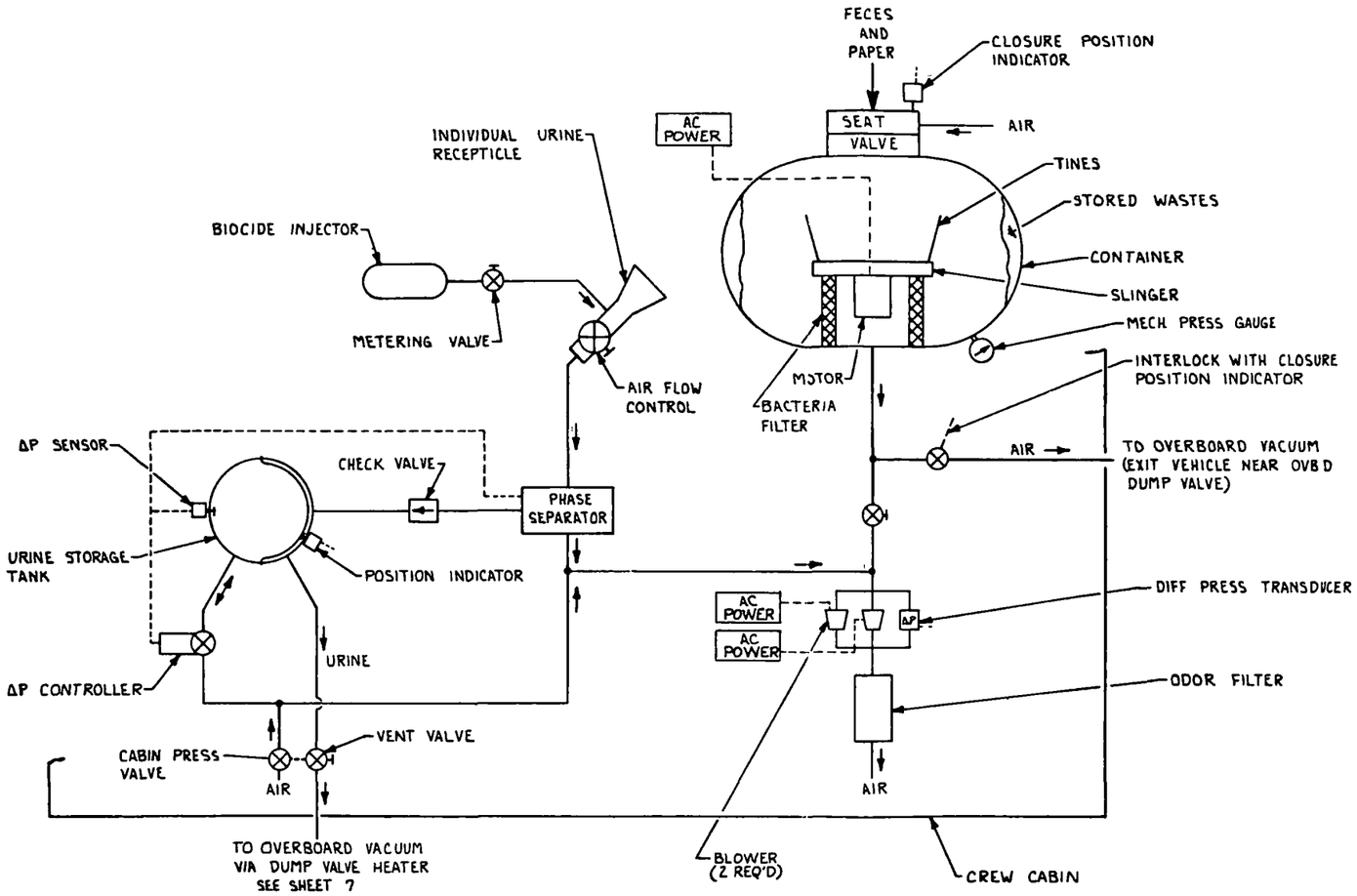
WEIGHT SUBSTANTIATION

PRODUCT WATER SYSTEM - SEE PG 2.14-26 FOR SCHEMATIC

ITEM	REF. NO. PG 2.14-60 TO 63	UNIT WEIGHT	QTY	TOTAL WEIGHT
(1) PRODUCT WATER ACCUM. MODULE	43.	18.4	2	36.8
(2) DUMP VALVE MODULE	44.	5.8	2	11.6
(3) PRESSURE CONTROL MOD.	44.	9.4	1	9.4
(4) PRESSURE RELIEF VALVE	45.	0.6	1	0.6
(5) AMPLIFIER & CONTROL	18.	1.5	2	3.0
(6) F.C. WATER ACCUMULATOR MODULE. *	43.	19.9	2	39.8
(7) CHECK VALVE	46.	0.11	2	0.22
(8) BACTERIA INHIBITOR	EST.	2.0	1	2.0
SUBTOTAL EQUIPMENT				(103.42)
PLUMBING & FITTINGS	EST.			11.0
CIRCUITRY & MISC.	13.	0.25	38	9.50
MOUNTING STR. ** $0.412(103.42 + 80\ LB.H_2O)^{.65}$	14.			12.19
TOTAL PRODUCT WATER SYSTEM				136.11 LB.

* NOTE: F.C ACCUMULATOR IS FULL AT LAUNCH FOR FUEL CELL COOLING IN THE EVENT OF AN ABORT (20 LB/TANK OR 40 LB. TOTAL IS SHOWN IN SECT. 2.25 RESERVE FLUIDS).

** H_2O FOR MTG PURPOSES ONLY - FULL H_2O CAP.



TOTAL WT. = 192 LB

REFERENCE: DESIGN NOTE
O-EAST-ECLS-02
WASTE MANAGEMENT
SUBSYSTEM STUDY

DR	D W RAY	2-10-71
CHK		
STR		
GR		

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
EASTERN DIVISION
SAINT LOUIS MISSOURI
MCDONNELL DOUGLAS CORPORATION

WASTE MANAGEMENT/ECLS
SYSTEM INTERFACE
ORBITER

SIZE	CODE IDENT NO	
	76301	255BJ00076 B

SCALE | WT | LB | SHEET 8 OF 10

(U)

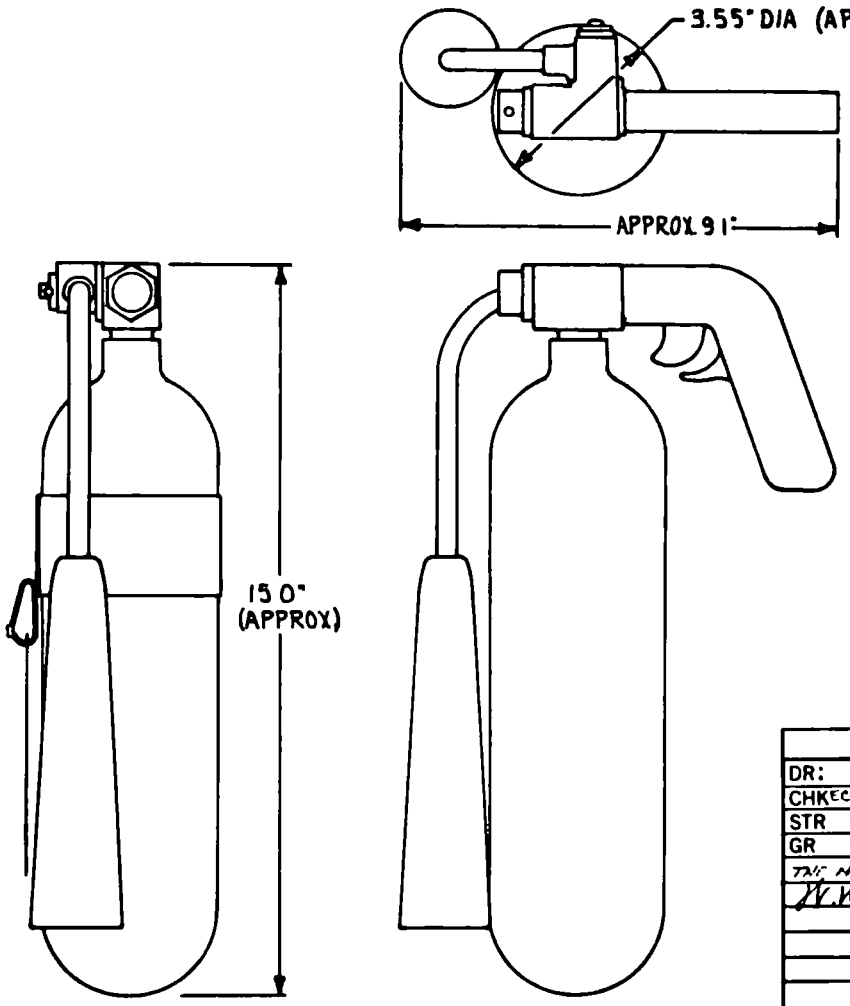
WEIGHT SUBSTANTIATION

WASTE MANAGEMENT SYSTEM - SEE PG. 2.14-28 FOR SCHEMATIC

ITEM	REF. NO. PG 2.14-60 TO 63	UNIT WEIGHT	QTY.	TOTAL WEIGHT
WASTE MANAGEMENT SYS.	47,	192.0	1	192.0
MOUNTING STR. $0.412(192)^{.65}$	14.			12.6
POWER CIRCUITRY $0.039(20\text{ LB MOTOR} + 10\text{ LB FAN})^{1.298}$	32.			3.2
CIRCUITRY & MISC.	13,	0.25	6	1.5
TOTAL WASTE MANAGEMENT SYSTEM				209.3 LB

FIRE EXTINGUISHING SYSTEM - SEE PG. 2.14-30

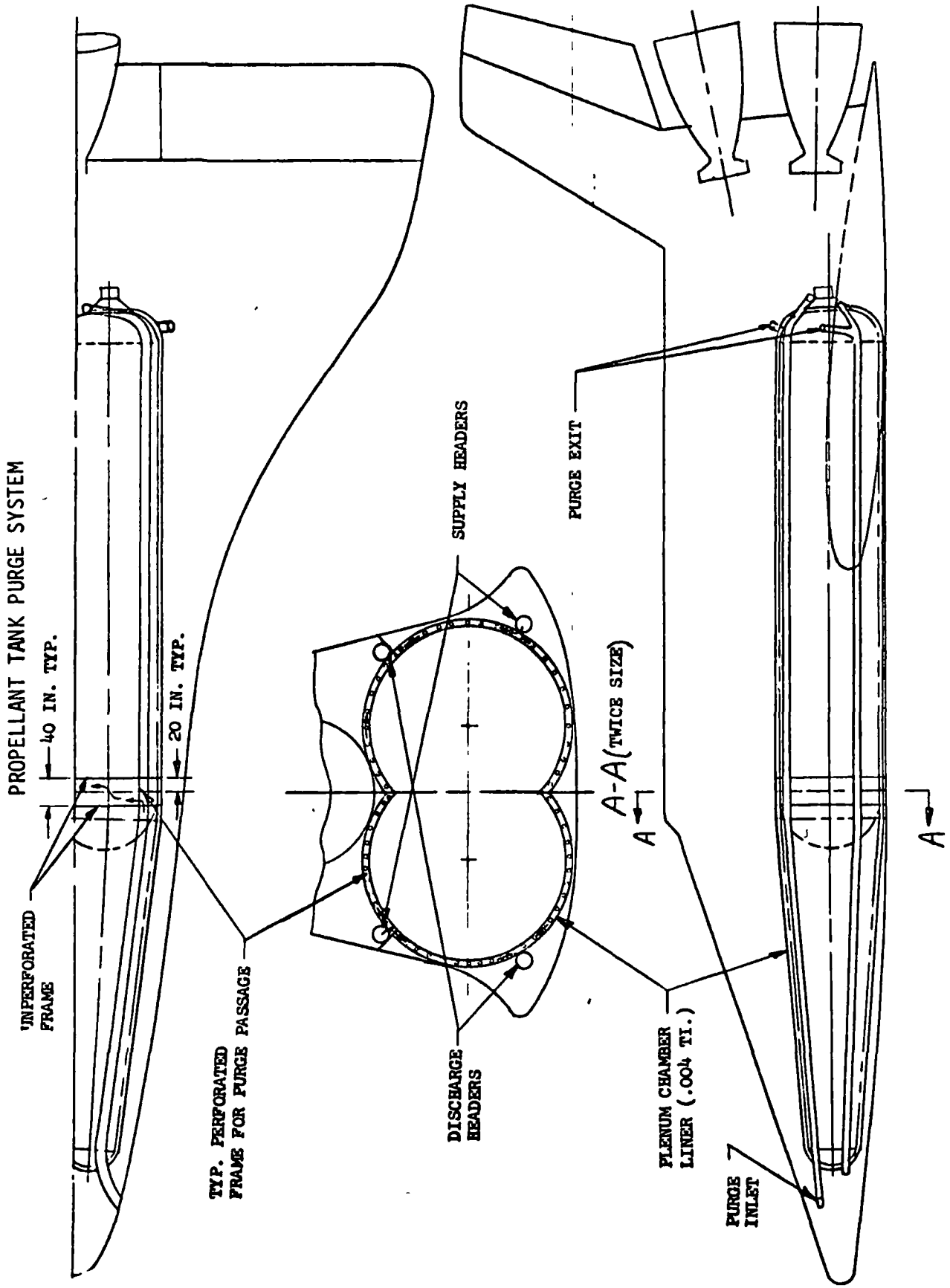
FIRE EXTINGUISHERS INCLUDE 2 LB. CO_2	49.	6.75	2	13.5
MOUNTING STR. $0.412(13.5)^{.65}$	14.			2.24
TOTAL FIRE EXTINGUISHING SYSTEM				15.74 LB.



NOTES.

1. THE FIRE EXTINGUISHING SYSTEM WILL CONSIST OF TWO OR MORE HAND-TYPE FIRE EXTINGUISHER, EACH CHARGED WITH APPROX 20 LBS OF CO_2.
2. FIRE EXTINGUISHERS WILL BE SIMILAR TO WALTER KIDDE MODEL 2TA.

DR: D W RAY	2-23 71	MCDONNELL DOUGLAS ASTRONAUTICS COMPANY EASTERN DIVISION SAINT LOUIS, MISSOURI MCDONNELL DOUGLAS CORPORATION
CHK ECLS		
STR		
GR		
		FIRE EXTINGUISHING SYSTEM -
SIZE	CODE IDENT NO 76301	255BJ00076 A
SCALE	WT LB	SHEET: 10 OF 10


PROPELLANT TANK PURGE SYSTEM
40 IN. TYP.
20 IN. TYP.
UNPERFORATED FRAME
TYP. PERFORATED FRAME FOR PURGE PASSAGE
SUPPLY HEADERS
DISCHARGE HEADERS
PURGE EXIT
A-A (TWICE SIZE)
A
A
PLENUM CHAMBER LINER (.004 TI.)
PURGE INLET

WEIGHT SUBSTANTIATION

PURGE LINER AREA

CALCULATION	AREA (FT^2)
$\pi \times 178 \times 785 = 438{,}975\ IN^2 = 3048\ FT^2$	
$\pi \times \frac{1}{2}(178 + 92) \times 536 = 227{,}326\ IN^2 = 1579\ FT^2$	
$(3048 + 1579) \times \frac{526^\circ}{360^\circ} =$	6761
$\pi \times \left[89^2 + \frac{66^2}{2 \times .6709} LOG_e \left(\frac{1 + .6709}{1 - .6709} \right) \right] \times 2 = 82{,}910\ IN^2 = 576\ FT^2$	
$\pi \times \left[46^2 + \frac{32^2}{2 \times .7184} LOG_e \left(\frac{1 + .7184}{1 - .7184} \right) \right] \times 2 = 21{,}394\ IN^2 = 149\ FT^2$	
$(576 + 149) \times \frac{4}{5} =$	580
TOTAL PURGE LINER AREA	(7341)

SUPPLY & DISCHARGE HEADER AREA

$\frac{1}{2}(1600 + 1480) \times 12 \times \pi \times 2 = 116{,}114\ IN^2 =$	807
$\frac{1}{2}(1600 + 1480) \times 10 \times \pi \times 2 = 96{,}762\ IN^2 =$	672
TOTAL SUPPLY & DISCHARGE HEADER AREA	(1479)

PURGE LINER WEIGHT

WT. = $7341\ FT^2 \times .004\ IN \times 144\ IN^2/FT^2 \times .16\ LB/IN^3$
= $7341\ FT^2 \times .0922\ LB/FT^2$
= <u>677 LB.</u>

SUPPLY & DISCHARGE HEADER WEIGHT

WT = $1479\ FT^2 \times .020\ IN \times 144\ IN^2/FT^2 \times .10\ LB/IN^3$
= $1479\ FT^2 \times .288\ LB/FT^2$
= <u>426 LB.</u>

TOTAL WT. = 677 + 426 = <u>1103 LB.</u>

WEIGHT SUBSTANTIATION

CALCULATION ~ E.C.L.S. INSULATION (3.5 LB/FT3 MICROQUARTZ)

CONFIGURATION →	HCR ORBITER			
REGION	BAY E/OR REGION INSUL	AREA FT²	QTY	UNIT WEIGHT** LB/FT²	TOTAL WEIGHT LB
AIR DCT/CARGO BAY EXP TUNNEL		82	1	0.41	34
CABIN WALL		405	1	0.41	166
AIRLOCK		210	1	0.41	86
P/R & COOL TRANS TUNNEL		1131	2	0.378	855
N.L.G. BAY		187	1	0.285	53
M.L.G. BAY OUT B'D LWR		200	2	0.992	397
UPR		200	2	0.306	122
SPEED BRAKE ACTS.		30	2	0.16	10
H TAIL OUTB'D ACTS LWR SURF.		71	2	0.835	119
H TAIL OUTB'D ACTS UPR SURF.		71	2	0.306	44
V. TAIL ACTS		44	2	0.71	63
N.L.G EQUIPMENT BAY		190	2	0.48	182
FWD. AVIONICS EQUIPMENT BAY *		466	2	0.29	270
AFT AVIONICS EQUIPMENT BAY		54	2	0.23	25
HYDRAULICS BAY		158	1	0.23	36
CRUISE ENG LWR		80	4	0.992	317
UPR		80	4	0.306	98
TOTAL WEIGHT ~ LB					2877

* INCLUDES ECLS BAY

** SEE FIGURE 2.14-59 FOR UNIT WEIGHT DERIVATION.

CURRENT INVENTORY OF FLUIDS AND PROPELLANTS

PAGE 1 OF 2

CONFIGURATION: DELTA WING ORBITER | BY | DATE

SYSTEM	MAX. DENSITY (LB/FT^3)	0% ULLAGE CAPACITY (LB)	TOTAL (LB)	EXPENDABLES (NOMINAL (LB)	INFLIGHT LOSSES (LB)	RESERVES (LB)	RESIDUALS (LB)
ENVIRONMENTAL CONTROL		[753]	[1047]	[0]	[324]	[102]	[621]
COOLING FLUID (FREON)	85	(435)	(435)	(0)	(0)	(0)	(435)
ATMOSPHERE (TOTAL)		(157)	(217)	(0)	(90)	(37)	(90)
OXYGEN (REPRESS & LEAK.-OAMS TK)		***	28	0	23	5	0
OXYGEN (METABOLIC - OAMS TK)		***	32	0	0	6	26
OXYGEN (EMERGENCY TANK)		17	17	0	0	16	1
DILUENT (N_2 TANK)(REPRESS & LEAK		81	81	0	67	10	4
ATMOSPHERE (INITIAL CABIN)		(59)	(59)	(0)	(0)	(0)	(59)
OXYGEN		15	15	0	0	0	15
DILUENT (N_2)		44	44	0	0	0	44
WATER	62.4	(161)	(161)	(0)	(0)	(65)	(96)
COOLING		136	136	0	0	40	96
** DRINKING		25	25	0	0	25	0
** WASH + PURIFICATION		N/A	N/A	N/A	N/A	N/A	N/A
COOLING CRYOGEN (H_2)		***	(234)	(0)	(234)	(0)	(0)
*** TANKED IN AUXILIARY PROPULSION TANKS.							
** PROVIDED BY FUEL CELLS, DRY WEIGHT INCLUDES WATER STORAGE AND COLLECTION PROVISIONS.							

* ONE RADIATOR CONTAINING TWO LOOPS PLUS TWO SEPARATE COOLING LOOPS ARE INTEGRATED AS A UNIFIED SYSTEM FOR PRIME POWER COOLING, AS WELL AS, LIFE SUPPORT AND AVIONICS EQUIPMENT MAINTENANCE.

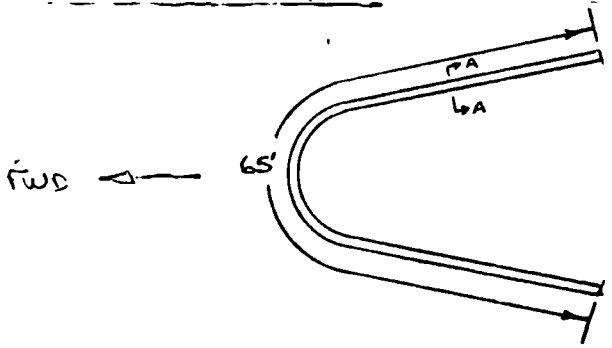
GAS USAGE REQUIREMENTS
4 MEN - 7 DAYS

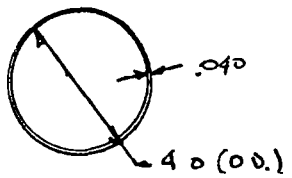
		QUANT. / RATE	TOTAL O_2	TOTAL N_2
LEAKAGE -	CABIN, AIRLOCK, & TUNNEL (.875 O_2 + 2.625 N_2)	3.5 LB/DAY	6.1	18.4
METABOLIC		1.84 LB/MAN-DAY	51.5	—
REPRESS -	CABIN (455 FT³) (.075 LB/FT³) (.25 O_2) (.75 N_2)		8.5	25.6
-	AIRLOCK (260 FT³)	" "	4.9	14.6
-	EXTENDED TUNNEL (121 FT³)	" "	2.3	6.8
WASTE MANAGE GAS DUMP			0.7	2.1
WATER TANK PRESSURANT			0.5	—
CONTINGENCY (15 %)			11.2	10.0
RESIDUAL (5 %)			* N/A	3.9
TOTAL PRIMARY GAS			85.7	81.4
OFF-LOAD 2 MEN - 7 DAYS			-25.7	—
TOTAL LOADED GAS			60.0	81.4
INITIAL PRESSURIZATION				
- CABIN	(455 FT³) (.075 LB/FT³) (.25 O_2) (.75 N_2)		8.5	25.6
- AIRLOCK	(260 FT³)	" "	4.9	14.6
- RETRACTED TUNNEL	(74 FT³)	" "	1.4	4.2
TOTAL INITIAL GAS			14.8	44.4
EMERGENCY OXYGEN				
- LEAKAGE	.875 LB/DAY × 2 DAYS		1.7	—
- METABOLIC	1.84 LB/MAN-DAY × 4 MEN - 2 DAYS		14.7	—
- RESIDUAL	(5 %)		0.8	—
TOTAL EMERGENCY OXYGEN			17.2	—

* STORED IN OAMS TANK, SEE SECT. 2.23 FOR RESIDUALS.

WEIGHT SUBSTANTIATION

CABIN AIR INLET DUCTS





$$V_{OL} = \pi \left(\frac{D_o^2 - D_i^2}{4}\right)_x L$$

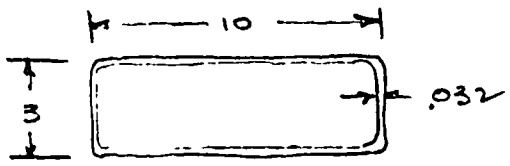
$$= 3.14 \left(\frac{4.00^2 - 3.92^2}{4}\right) .65\,FT \cdot 12 \frac{IN}{FT}$$

$$= 381\ IN^3$$

$$W_{FIGHT} = 381\ IN^3 \times 0.103 \frac{LB}{IN^3} = \underline{\underline{39.2\ LB.}}$$

CABIN AIR OUTLET DUCTS

THE AIR OUTLET DUCTS ARE ASSUMED TO BE OVERHEAD

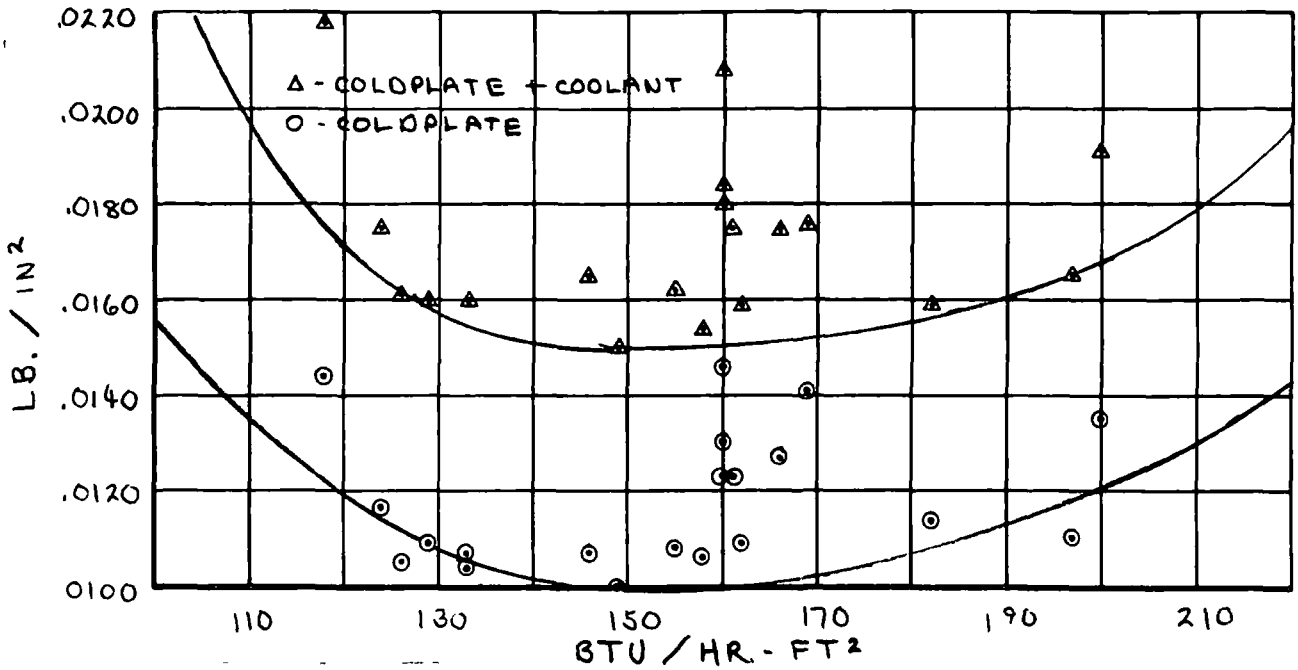


$$W_T = (10+10+3+3) \cdot .032 \cdot 160\,FT \cdot 12 \frac{IN}{FT} \times 0.103 \frac{LB}{IN^3} = \underline{\underline{163.5\ LB}}$$

WINDOW DEFOGGER DUCT WEIGHT IS ASSUMED TO BE IN THE ABOVE.

WEIGHT SUBSTANTIATION

GEMINI COLDPLATE ACTUAL DATA



BASED ON THE GEMINI ACTUAL DATA SHOWN ABOVE AND USING A VALUE OF 160 BTU/HR-FT² FOR HEAT TRANSFER, THE FOLLOWING UNIT WEIGHT DERIVATION IS USED TO CALCULATE THE EQUIPMENT COLD PLATE WEIGHT SHOWN ON PAGE 2 14- .

$$160 \frac{BTU}{HR-FT^2} \times 17.58 \frac{WATTS}{BTU/MIN} \times \frac{1}{60\ MIN/HR} = 46.88 \frac{WATTS}{FT^2}$$

$$0.0100 \frac{LB}{IN^2} \times 144 \frac{IN^2}{FT^2} = 1\,44 \frac{LB}{FT^2}$$

$$46.88 \frac{WATTS}{FT^2} \times \frac{1}{1.44\ LB/FT^2} = 32.56 \frac{WATTS}{LB}$$

$$\frac{1}{32.56\ WATTS/LB} = \underline{\underline{0.0307 \frac{LB}{WATT}}}$$

GEMINI DATA INDICATES FLUID WT. = 1/2 COLD PLATE DRY WT., HOWEVER MCS-198, DENSITY = 0.032 LB/IN³, FREON = 0.0492 LB/IN³ AND H_2O = 003612 LB/IN³. FACTORS USED ARE ADJUSTED ACCORDINGLY.

WEIGHT SUBSTANTIATION

COLD PLATE ANALYSIS

LOCATION	UNIT	OPER. POWER WATTS/UNIT (1)	COLD PLATE WEIGHT (DRY) (1) X 0.307 LB/WATT	QTY.	TOTAL COLD PLATES WT (DRY)
NAV BASE	IMU	150	4.605	4	18.42
"	STAR TRACKER	69	2 118	3	6 35
"	HORIZ SENSOR	60	1.842	4	7.37
"	NAV. BASE DIV.	5	0.15	4	0.61
	SUBTOTAL NAVIGATION BASE				(32.15)
CABIN &/OR CREW STA.	SCU	52	1.60	1	1 60
"	CREW DIV'S	10	0.307	24	7 37
"	AUDIO CONTROL CENTER	20	0.614	3	1 84
"	INTERCOM	15	0.460	1	0 46
"	DOCK STATION	20	0.614	1	0 61
"	CRT	127	3 899	3	11 70
"	SYM. GEN.	168	5.158	3	15 47
"	MICROVWR	16	0 491	3	1 47
	SUBTOTAL CABIN &/OR CREW STATION				(40 52)
NOSE WELL	THRUST ELEC.	30	0.921	6	(5 53)
MLG. WELL	ALTIMETER	100	3.07	3	(9 21)
AFT BAY	THRUST ELEC.	30	0.921	2	1 84
"	ACT ELEC.	90	2 763	4	11 05
"	RATE GYRO	15	0.46	4	1 84
"	TOTAL TEMP. & PR	5	0.153	4	0 61
"	ACCEL.	3	0 092	4	0 37
"	AREA DIV.	15	0 46	12	5 53
	SUBTOTAL AFT BAY				(21 24)

WEIGHT SUBSTANTIATION

COLD PLATE ANALYSIS - CONT.

LOCATION	UNIT	OPER. POWER WATTS/UNIT (1)	COLD PLATE WT (DRY) (1) x 0307 LB/WATT	QTY	TOTAL COLD PLATES WT (DRY)
FWD. BAY	STATIC PRESS.	5	0.153	4	0.61
"	COMPUTER	450	13.815	4	55.26
"	MASS MEM.	60	1.84	2	3.86
"	MAINT. RECORD	125	3.84	2	7.68
"	AREA DIV.	15	0.46	12	5.53
"	IOCU	20	0.614	4	2.46
"	S-BAND	75	2 30	3	6 91
"	UHF	100	3.07	2	6 14
"	DME	75	2.30	3	6.91
"	GS	6	0.18	3	0.55
"	VOR/LOC	80	2.46	3	7.37
	SUBTOTAL FORWARD BAY				(103.28)
	TOTAL COLD PLATES (DRY)			212.53	LB.

COLD PLATES SUMMARY

LOCATION	TOTAL DRY WEIGHT	FLUID FACTOR	TOTAL FLUID WT.
NAV. BASE	32.75	0,7688	25.18
CABIN &/OR CREW STA.	40 52	0 5644	22 87
NOSE WELL	5.53	0.7688	4.25
MLG WELL	9.21	0.7688	7.08
AFT BAY	21.24	0.7688	16.33
FORWARD BAY	103.28	0.7688	79.40
TOTAL	212.53		155.11

WEIGHT SUBSTANTIATION

TEMPERATURE CONTROL PANELS

NOSE LANDING GEAR PANEL

EST. AT 1.5 FT^2 - ASSUME SIMILAR TO COLD PLATE DESIGN (REF. PG. 2.14-)

WT. (DRY) = 1.5 FT^2 x 144 IN^2/FT^2 x 001 LB/IN^2

= 2.16 LB

MAIN LANDING GEAR PANEL (SAME AS NOSE)

WT. (DRY) = 2.16 LB. EACH (2 REQUIRED)

AIR BREATHING ENGINE PANEL

INLET APPROXIMATELY 45.5 IN. DIAMETER (4 REQUIRED)

$WT.(DRY) = \frac{\pi}{4}(45.5)^2 (0.01\ LB/IN^2)$

= 16.3 LB. EACH

OUTLET APPROXIMATELY 29 3 IN. DIAMETER (4 REQUIRED)

$WT.(DRY) = \frac{\pi}{4}(29\ 3)^2 (0.01\ LB/IN^2)$

= 6.7 LB. EACH

WEIGHT SUBSTANTIATION

HEAT TRANSPORT SYSTEM

COOLANT REQUIREMENTS

BASED ON GEMINI HARDWARE DATA WITH MCS-198 (MMS-602) COOLANT (0.032 LB/IN^3 @ 70° F.). IN GENERAL:

FOR LIQUID/LIQUID H.X.'s, WT. OF COOLANT = $\frac{1}{2}$ [H.X. (DRY) WT.]

FOR GAS/LIQUID H.X.'s, WT. OF COOLANT = 0.11 [H.X. (DRY) WT.]

THEREFORE FOR CABIN WATER LOOP:

LIQUID/LIQUID H.X.'s, WT. OF H_2O = $0.5 \times \frac{0.03612}{0.032}$ [H.X. (DRY) WT.]

= 0.5644 [H.X. (DRY) WT.]

GAS/LIQUID H.X.'s, WT. OF H_2O = $0.11 \times \frac{0.03612}{0.032}$ [H.X. (DRY) WT.]

= 0.1242 [H.X (DRY) WT.]

WT. OF COOLANT/PUMP = 1.8 LB (MCS-198) THEREFORE:

WEIGHT OF H_2O/PUMP = $1.8 \times \frac{0.03612}{0.032}$ = 2.03 LB.

CORRESPONDINGLY, FREON LOOP REQUIREMENTS:

LIQUID/LIQUID H.X.'s, WT. OF FREON = $0.5 \times \frac{0.0492}{0.032}$ [H.X. (DRY) WT.]

= 0.7688 [H.X. (DRY) WT.]

GAS/LIQUID H.X.'s, WT. OF FREON = $0.11 \times \frac{0.0492}{0.032}$ [H.X. (DRY) WT.]

= 0.1691 [H.X. (DRY) WT.]

WT. OF FREON/PUMP = $1.8 \times \frac{0.0492}{0.032}$ = 2.77 LB.

WEIGHT SUBSTANTIATION

CABIN COOLANT LOOP

WATER CALCULATION

ITEM	CALCULATION	QTY	WEIGHT OF WATER
CONDENSING H.X	0.1242 × 31.0 = 3.85	1	3.85
CABIN H.X.	0.1242 × 49.7 = 6.17	1	6.17
WINDOW DEFOGGER H.X	0.1242 × 53.0 = 6.58	1	6.58
SUBTOTAL AIR LOOP			(16.60)
COOLANT PUMP	2.03 LB/PUMP	4	8.12
RESERVOIR	10 IN^3 × 0.03612 LB/IN^3 = 0.36	2	0.72
COLD PLATES	0.5644 × 40.52 = 22.87	1	22.87
INTERFACE H.X.	0.5644 × 46.4 × $\frac{1}{2}$ = 13.09	2	26.19
SUBTOTAL COOLANT LOOP			(74.50)
PLUMBING	0.0383 IN^3/IN × 200 FT × 12 IN/FT × 0.03612 LB/IN^3 =		5.05
TOTAL WATER IN SYSTEM			96.15 LB
[illegible] WATER IN FC ACCUMULATORS	20 LB EA × 2 REQ'D =		40.0
TOTAL COOLING WATER			136.15 LB
[illegible] WATER IN CABIN @ 25 LB CAPACITY (REF. SECT 2.15 FOR DRINKING WATER TANK)			25. LB

WEIGHT SUBSTANTIATION

EQUIPMENT COOLANT LOOP

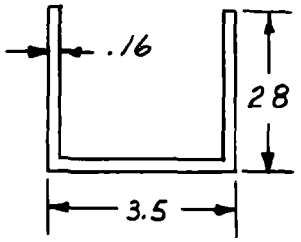
FREON CALCULATION

ITEM	CALCULATION	QTY.	WEIGHT OF FREON
INTERFACE H.X.	$0.7688 \times 46.4 \times \frac{1}{2} = 17.84$	2	35.67
COOLANT PUMP	2.77 LB/PUMP	4	11.08
RESERVOIR	$57\ IN^3 \times 0.0492\ LB/IN^3 = 2.80$	2	5.61
TEMPERATURE CONTROL PANEL N.L.G.	$0.7688 \times 2.16 = 1.66$	1	1.66
TEMPERATURE CONTROL PANEL ABES. INLET	$0.7688 \times 16.3 = 12\ 53$	4	50 13
TEMPERATURE CONTROL PANEL ABES. OUTLET	$0.7688 \times 6.7 = 5.15$	4	20.60
TEMPERATURE CONTROL PANEL M.L.G.	$0.7688 \times 2.16 = 1\ 66$	2	3.32
AFT EQ. BAY COLD PLATES	$07688 \times 21.24 = 16.33$	1	16.33
MLG WELL COLD PLATES	$0.7688 \times 9.21 = 708$	1	7.08
N.L.G. WELL COLD PLATES	$0.7688 \times 5.53 = 4\ 25$	1	4 25
FWD. EQ. BAY COLD PLATES	$07688 \times 103.28 = 79.40$	1	79.40
GROUND COOLING H.X.	$0.7688 \times 9.2 = 7.07$	1	7.07
CRYOGENIC H.X.	$0.1691 \times 24 = 406$	4	16.23
SUBTOTAL EQUIPMENT LOOP			(258.43)
SPACE RADIATOR (REF. PAGE 2 14-48)		1	40.80
PLUMBING	$0.1662\ IN^3/IN \times 690\ FT \times 2 \times 12\ FT \times 0.0492\ LB/IN^3 =$		135 41
TOTAL FREON IN SYSTEM			434.64 LB.

RADIATOR ASSEMBLY - WEIGHT SUBSTANTIATION

ALL PARTS ALUMINUM EXCEPT HINGE.

EDGE MEMBER - LATCH EDGE (REF DWG 255BJ30083)

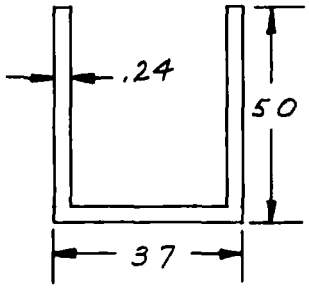


FOR END AND LATCH LUG DETAIL SEE REF. DWG

ENDS 98 IN^3 @ 6 PLCS.
LUGS 8.1 IN^3 @ 7 PLCS.

WEIGHT = .100 × [.16 × 495 × (3.5 + 2.8 + 2.8) + 6 × 98 + 7 × 8.1] = 83.62 LB

EDGE MEMBER - HINGE EDGE (REF DWG 255 BJ30083)

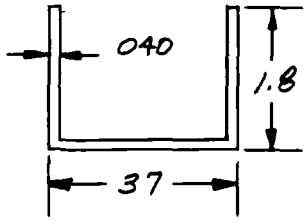


FOR END AND HINGE LUG DETAIL SEE REF. DWG

ENDS 3.7 IN^3 @ 6 PLCS
LUGS 5.3 IN^3 @ 13 PLCS

WEIGHT = .100 × [.24 × 495 × (3.7 + 5.0 + 5.0) + 6 × 3.7 + 13 × 5.3] = 171.47 LB.

END FRAME - 1 REQ'D/PANEL (REF DWG 255BJ30083)

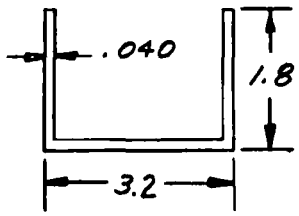


LENGTH = 231 IN.

WEIGHT = 100 × .040 × (3.7 + 1.8 + 1.8) × 231 = 6.73 LB.

RADIATOR ASSEMBLY - WEIGHT SUBSTANTIATION

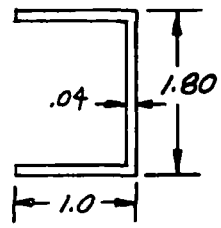
FRAME - 2 REQ'D/PANEL (REF DWG 255BJ30083)



LENGTH = 231 IN

WEIGHT = .100 × 040 × (3.2 + 1.8 + 1.8) × 231 = 6.28 LB.

INTERCOSTAL - 10 REQ'D/PANEL (REF DWG 255BJ30083)



FOR END DETAIL SEE REF. DWG.
ENDS .3 IN³ @ 1 PLC.
LENGTH = 67 IN (1 PANEL), 80 IN (6 PANELS)

WEIGHT = .100 × [.040 × (1.8 + 1.0 + 1.0) × 67. + .3] = 1.04 LB

= .100 × [.040 × (1.8 + 1.0 + 1.0) × 80. + .3] = 1.23 LB.

PANEL SKIN (REF DWG 255BJ30100)
.036 CHEM-MILLED ALUMINUM

UNIT WEIGHT = .100 × 036 × 144 = .518 LB/FT²

HINGE (REF DWG 255BJ30083)

HARMONIC DRIVE 13 UNITS @ 2.4 LB. 31.2 LB.

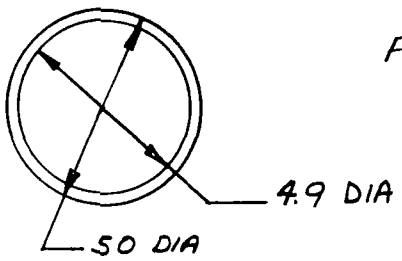
RADIATOR ASSEMBLY - WEIGHT SUBSTANTIATION
(AFT COMP.)

SUPPORT TUBE - TITANIUM

LENGTH = 495 IN

FOR CLAMP FITTING DETAIL SEE REF. DWG.

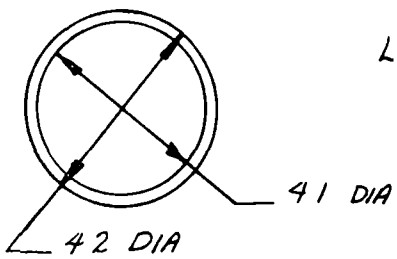
CLAMP FTG = 53 IN^3 @ 6 PLCS



$$\text{WEIGHT} = .160 \times \left[\frac{\pi}{4} \times (50^2 - 4.9^2) \times 495 + 6 \times 5.3\right] = \underline{66.67 \text{ LB.}}$$

DRIVE TUBE - TITANIUM

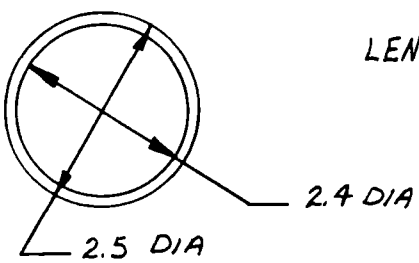
LENGTH = 495 IN



$$\text{WEIGHT} = .160 \times \frac{\pi}{4} \times (4.2^2 - 4.1^2) \times 495. = \underline{51.63 \text{ LB.}}$$

TORQUE TUBE - TITANIUM

LENGTH = 495 IN



$$\text{WEIGHT} = .160 \times \frac{\pi}{4} \times (2.5^2 - 2.4^2) \times 495 = \underline{30.48 \text{ LB.}}$$

TOTAL HINGE WEIGHT = 31.2 + 66.67 + 51.63 + 30.48 = 179.98 LB.

RADIATOR ASSEMBLY - WEIGHT SUBSTANTIATION

TUBING (REF. DWG. 255BJ30100)

MAIN FEED LINES ½ DIA -.020 WALL - .0030 LB/IN
RADIATOR COILS 3/16 DIA-.020 WALL - .0011 LB/IN
FLEXIBLE LINES ½ DIA ST. STEEL - 030 LB/IN

TUBING LENGTH'S
(SEE 255BJ30100 FOR ROUTING PATH AND 255BJ30083 FOR PANEL NUMBERS.)

PANEL NO.	TUBING LENGTH		NO. OF FITTINGS	
	3/16"	½"	3/16"	½"
1	2952"	241"	12	4
2	3900"	320"	16	8
3-7	SAME AS 2		SAME AS 2	

TUBING WELDS (REF DWG 255BJ30100)

UNIT WEIGHT = .0019 LB/IN (2 WELDS/TUBE)

PANEL WEIGHTS

#1 PANEL 67"×231"

SKIN	.518×67×231/144	= 55.67
TUBING-FTGS	2952×.0011+241×.0030+16×.042	= 3.97
WELDS	2780×.0019	= 5.29
INTERCOSTALS	10×104	= 10.40
END FRAME		= 6.73
FRAMES		= 12.56
TOTAL #1 PANEL		94.62

RADIATOR ASSEMBLY - WEIGHT SUBTANTIATION

#2 PANEL 80" × 231"

SKIN	518 × 80 × 231/144	= 66.48
TUBING-FTGS	3900 × .0011 + 320 × .0030 + 16 × .042	= 5.25
WELDS	3700 × .0019	= 7.04
INTERCOSTAL	10 × 1.23	= 12.30
END FRAME		= 6.73
FRAMES		= 12.56
TOTAL #2 PANEL		110.36
TOTAL PANELS #2-#7		662.16

TOTAL PANEL WEIGHT = 94.62 + 662.16 = 756.78 LB.

FLEXIBLE LINES & FITTINGS (REF. DWG 255BJ30100)

LINES	4 × 30 × .03	= 3.60
FTGS	8 × .253	= 2.02
TOTAL		5.62 LB.

LINE CAPACITY

3/16"	.0171 IN^3/IN × 26352 IN	=	450.6 IN^3
1/2"	.1662 IN^3/IN × 2281 IN	=	379.1 IN^3
TOTAL CAPACITY			829.7 IN^3

WEIGHT OF FLUID (FREON) .0492 × 829.7 = 40.8 LB.

RADIATOR ASSEMBLY - WEIGHT SUBSTANTIATION

WEIGHT SUMMARY

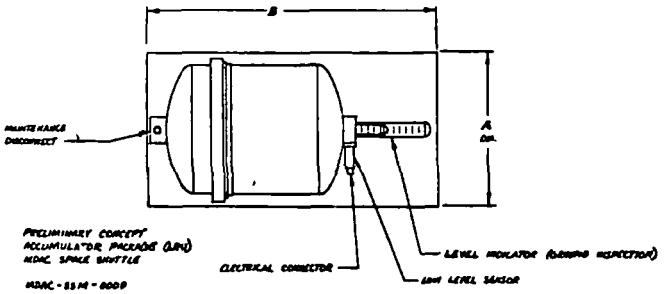
PANELS	756.78	
LATCH EDGE MEMBER	83.62	
HINGE EDGE MEMBER	171.47	
HINGE	179.98	
FLEX LINES	5.62	
MOTORS & VALVES & MOUNTS	20.00	**
CLUTCH MECHANISM	20.00	**
TRANSMISSION SYS	35.00	**
TOTAL WEIGHT (DRY)	1197.47	
FLUID	40.80	
TOTAL WEIGHT (WET)	1238.27	

** REFERENCE WEIGHT ONLY. NOT INCLUDED IN TOTALS. ALSO USED AS DRIVE SYSTEM FOR PAYLOAD DOOR. SEE SECTION 2.3.

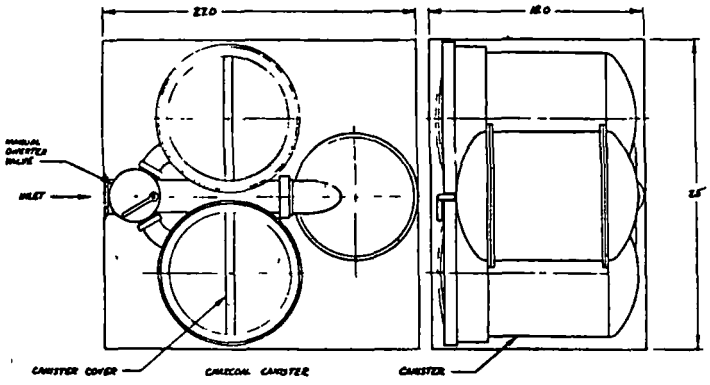
SYSTEM DESCRIPTION	DIMENSIONS (IN.) A DIA	B	WEIGHT (LB)
CABIN TEMPERATURE LOOP (SYSTEM 41)	12.0	23.0	12.0
CABIN CO2 LOOP (SYSTEM 42)	8.0	11.0	2.3

WEIGHT SUBSTANTIATION

REFERENCE DATA TAKEN FROM ENVIRONMENTAL CONTROL AND LIFE SUPPORT MDAC MEMO NO. SSPI-E450-588

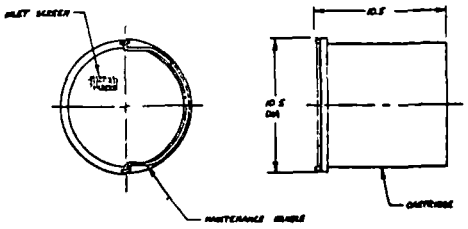


PRELIMINARY CONCEPT
ACCUMULATOR PACKAGE (LAN)
MDAC SPACE SHUTTLE
MDAC - SSM - 6009



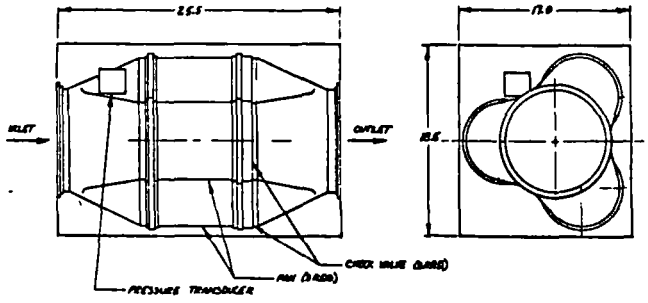
PACKAGE WEIGHT = 61.8 LB WITH 5 LION CARTRIDGES INSTALLED
51.8 – 15.5 = 50.8 LBS W/O LION CARTRIDGES

PRELIMINARY CONCEPT
LITHIUM HYDROXIDE PACKAGE
MDAC SPACE SHUTTLE
MDAC - SSM - 6010



CARTRIDGE WEIGHT = 15.5 LB EACH
9 REQ'D PER 28 MAN DAY FLIGHT

PRELIMINARY CONCEPT
LITHIUM HYDROXIDE CARTRIDGE
MDAC SPACE SHUTTLE
MDAC - SSM - 6011

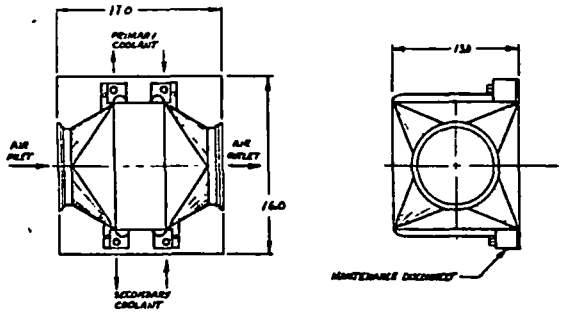


FAN MODULE WEIGHT = 25.7 LB.

PRELIMINARY CONCEPT
AIRFLOW FAN MODULE
MDAC SPACE SHUTTLE
MDAC - SSM - 6042

WEIGHT SUBSTANTIATION

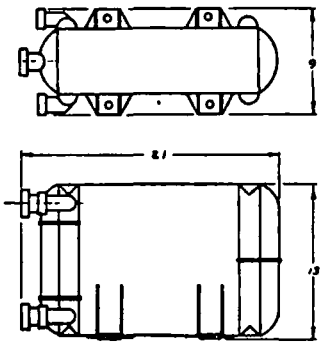
REFERENCE DATA TAKEN FROM ENVIRONMENTAL CONTROL AND LIFE SUPPORT MDAC METHOD SSPI-E450-588

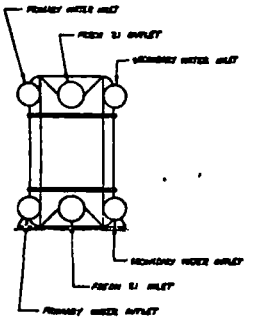


HEAT EXCHANGER WEIGHT = 49.7 LB. DRY

PRELIMINARY CONCEPT
CABIN SENSIBLE HEAT EXCHANGER
MDAC SPACE SHUTTLE

MDAC-S3M-0043

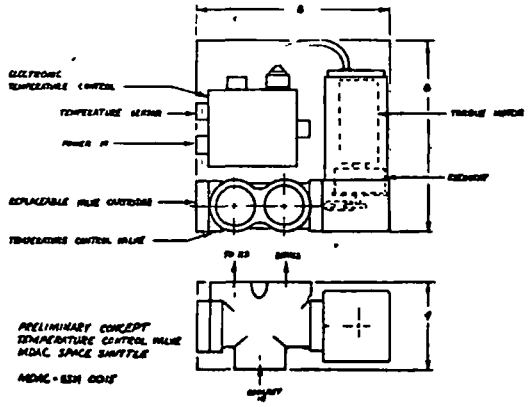




HEAT EXCHANGER DRY WGT 46.4 LB.

PRELIMINARY CONCEPT
INTERFACE HEAT EXCHANGER
MDAC SPACE SHUTTLE

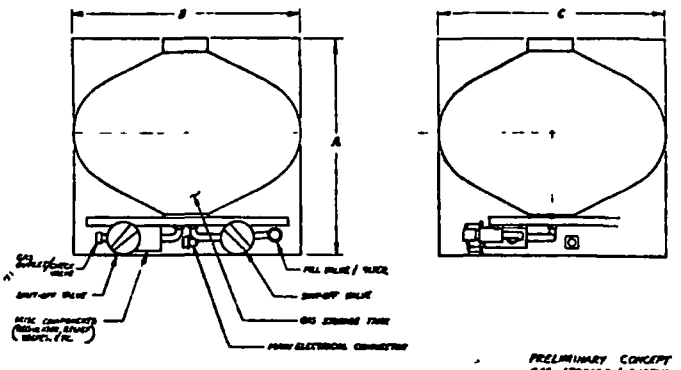
MDAC-S3M-0041



PRELIMINARY CONCEPT
TEMPERATURE CONTROL VALVE
MDAC SPACE SHUTTLE

MDAC-S3M 0015

SYSTEM	NO. REQ'D	WT EA. LBS	DIM A	DIM B & C	TOTAL GAS WGT LBS
PANEL O_2 SUPPLY	1	21	19	20	17 %
N_2 SUPPLY	2	50	28 5	28	40.7 / TANK



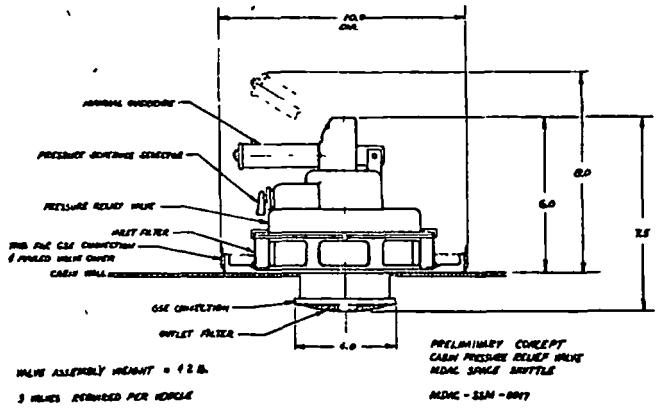
NOTES:
1. WEIGHT DOES NOT INCLUDE TANK STRUCTURAL SUPPORTS.

PRELIMINARY CONCEPT
GAS STORAGE & SUPPLY
MDAC SPACE SHUTTLE

MDAC-S3M-0044

WEIGHT SUBSTANTIATION

REFERENCE DATA TAKEN FROM ENVIRONMENTAL CONTROL AND LIFE SUPPORT MDAC MEMO. SSPI-E450-588

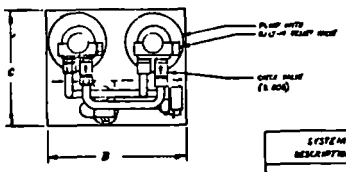


PRELIMINARY CONCEPT
CABIN PRESSURE RELIEF VALVE
MDAC SPACE SHUTTLE

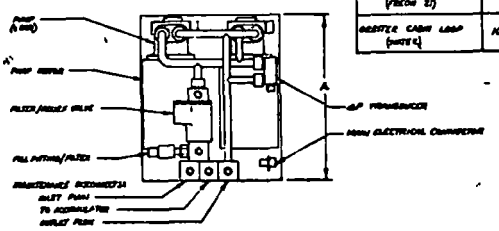
MDAC - SSM - 0017

VALVE ASSEMBLY WEIGHT = 4.2 lb.

3 VALVES REQUIRED PER VEHICLE

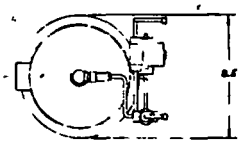


SYSTEM DESCRIPTION	DIMENSIONS (in) A	B	C	WEIGHT (lb)
DESIRED COMPONENT LOOP (FREON 21)	16.0	15.0	12.0	29.5
DESIRED CABIN LOOP (WATER)	10.0	9.0	8.0	15.0

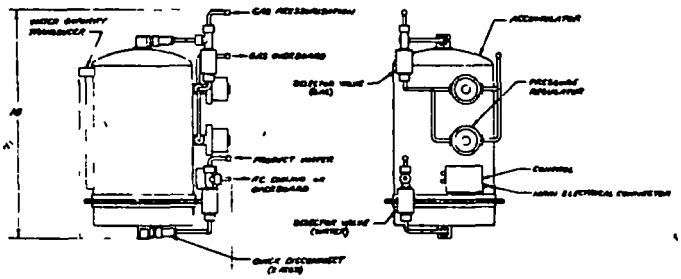


PRELIMINARY CONCEPT
COOLANT PUMP PACKAGE
MDAC SPACE SHUTTLE

MDAC - SSM - 0018

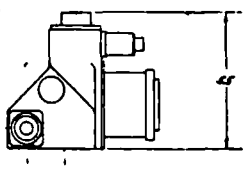


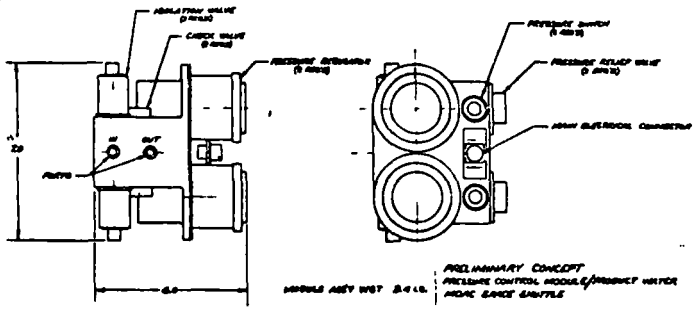
PACKAGE	WET lb/PKG	PACKAGES/VEHICLE
FUEL CELL COOLANT WATER ACCUMULATOR PKG	19.9	3
EXCESS WATER ACCUMULATOR PKG.	18.4	3



PRELIMINARY CONCEPT
WATER ACCUMULATOR PACKAGE
MDAC SPACE SHUTTLE

MDAC - SSM - 0020



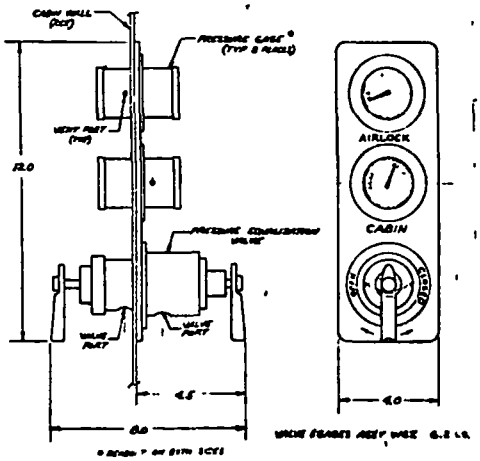


PRELIMINARY CONCEPT
PRESSURE CONTROL MODULE & PRESSURE WATER
MDAC SPACE SHUTTLE

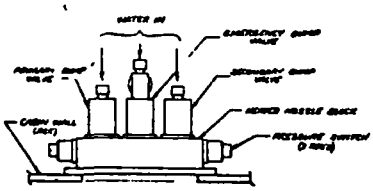
MDAC - SSM - 0021

WEIGHT SUBSTANTIATION

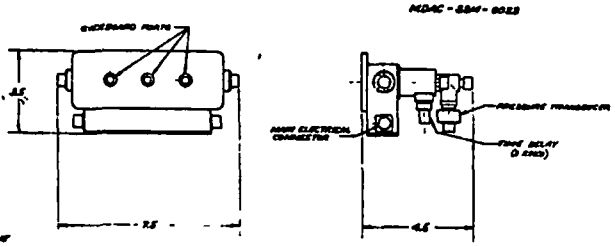
REFERENCE DATA TAKEN FROM ENVIRONMENTAL CONTROL AND LIFE SUPPORT MDAC MEMO NO SSPI-E450-588

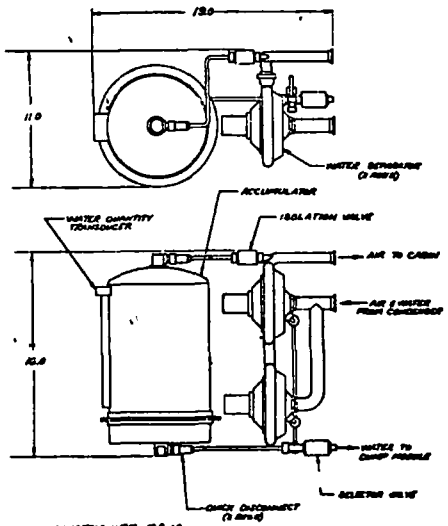


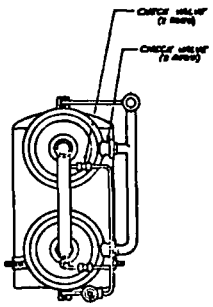
PRELIMINARY CONCEPT
PRESSURE CONSULATION VALVE & GAGES
MDAC SPACE SHUTTLE



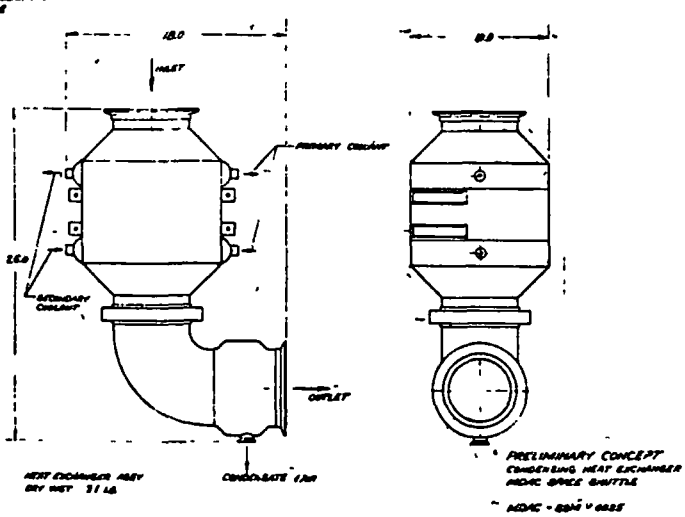
PRELIMINARY CONCEPT
WATER DUMP SYSTEM MODULE
MDAC SPACE SHUTTLE



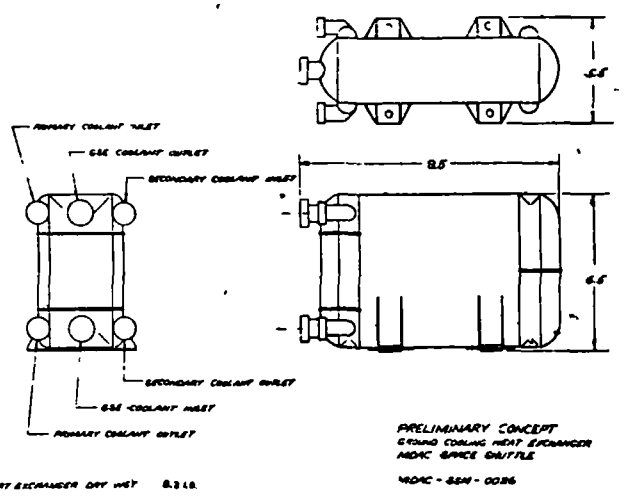




PRELIMINARY CONCEPT
CONDENSATE WATER SUBSYSTEM
MDAC SPACE SHUTTLE



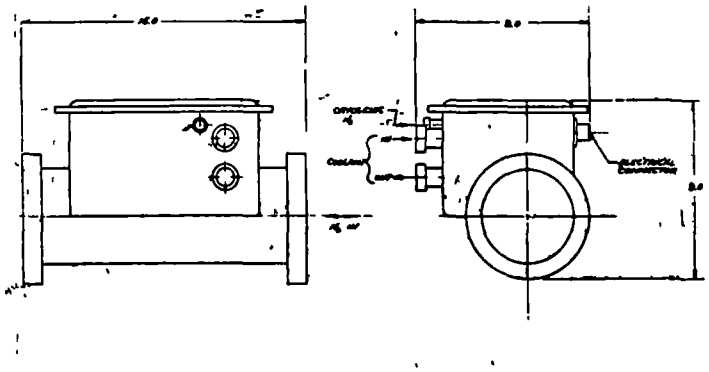
PRELIMINARY CONCEPT
CONDENSING HEAT EXCHANGER
MDAC SPACE SHUTTLE



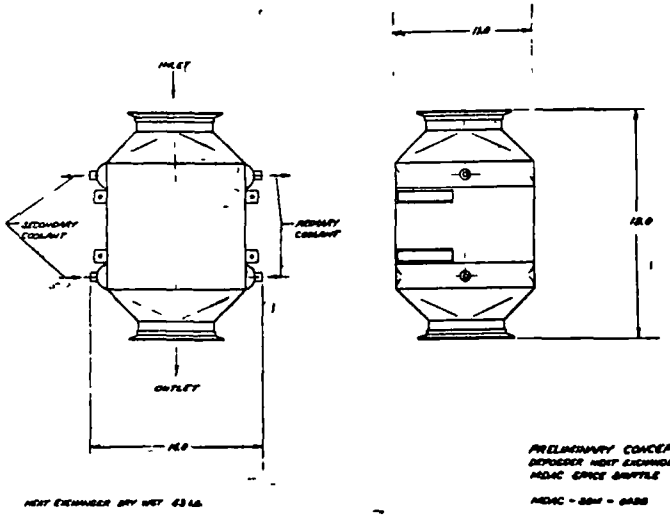
PRELIMINARY CONCEPT
GROUND COOLING HEAT EXCHANGER
MDAC SPACE SHUTTLE
MDAC - ESM - 0086

WEIGHT SUBSTANTIATION

REFERENCE DATA TAKEN FROM ENVIRONMENTAL CONTROL AND LIFE SUPPORT MDAC MEMO NO SSPI-E450-588



PRELIMINARY CONCEPT
CRYOGENIC HEAT EXCHANGER RADIATOR
MDAC SPACE SHUTTLE
MDAC - ESM - 0087



PRELIMINARY CONCEPT
DEPOSITOR HEAT EXCHANGER
MDAC SPACE SHUTTLE
MDAC - ESM - 0088

WEIGHT SUBSTANTIATION

ECLS Insulation Unit Weight Calculations - Basic TPS insulation (Reference section 2.4) is provided to maintain a design structural limit of 300°F. The cabin and equipments, however, require lower design temperatures, therefore, additional insulation is provided locally to protect the cabin and other regions where equipment is installed.

Basic Ground Rules and Assumptions

1. Assumed equipment and structure maximum design temperatures are as follows:

o Main Propulsion System Tank	300°F*
o Wing and Carry Through Structure	600°F
o Cabin, ext. tunnel and airlock	160°F
o Radiator and Cargo Compartment	300°F*
o Landing Gear	250°F
o Hydraulic Actuators	250°F
o Cruise Engines	250°F
o Electronics, ECS and all other equipment	200°F

*Therefore, no additional ECLS insulation is required.

2. External temperatures and general equipment locations are shown on page 2.14- .

3. Basic insulation unit weights for various substructure temperatures are given on pages 2.14- and . Page 2.14- shows a sample of the method used to determine the net ECLS insulation required. Page 2.14- gives the complete detail analysis of net insulation requirements and total unit weights.

4. Surface areas used to determine ECLS insulation weights are based on orbiter general equipment arrangement drawings and detail equipment bay drawings.

5. It is assumed that (5) sided bagging is required for all ECLS insulation. 2 Mil Kapton bagging is used in all areas where the temperature does not exceed 600°F.

6. Power and coolant line transfer tunnel length is based on orbiter general arrangement drawings and with a 21" x 5" assumed rectangular cross section.

7. Data shown on pages 2.14- and - are based are early trajectory analyses. The following gives a comparison between "old" data used here and "new" present baseline trajectory data.

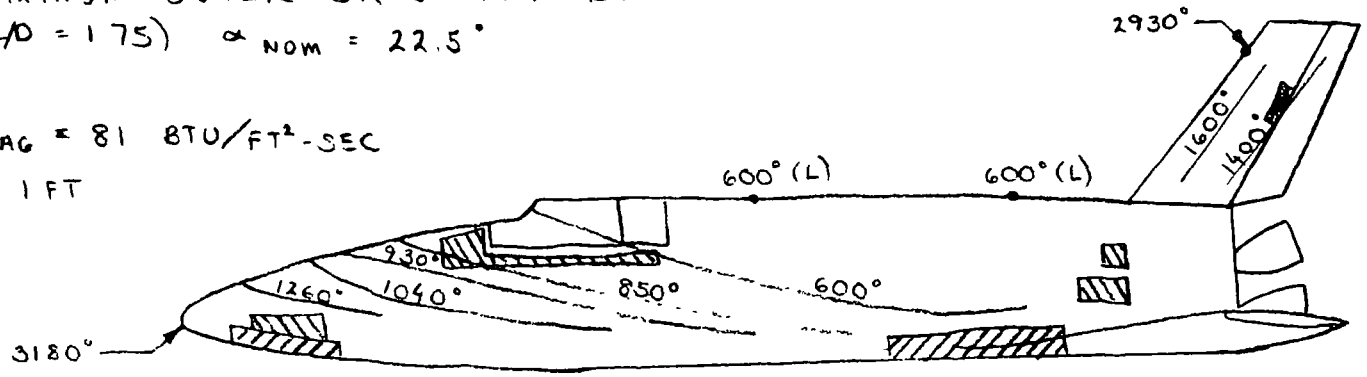
	"old"	"new"
o Fuselage bottom temperature		-200°F
o Lower wing/upper fuselage temperature	≈ Same	≈ Same
o Total heat bottom ℄ @ X/L = 25% aft	16,086 BTU/ft^2	15,241 BTU/ft^2 (down approx 5%)

Therefore, data shown here is assumed relatively accurate for measuring insulation requirements for the present baseline design.

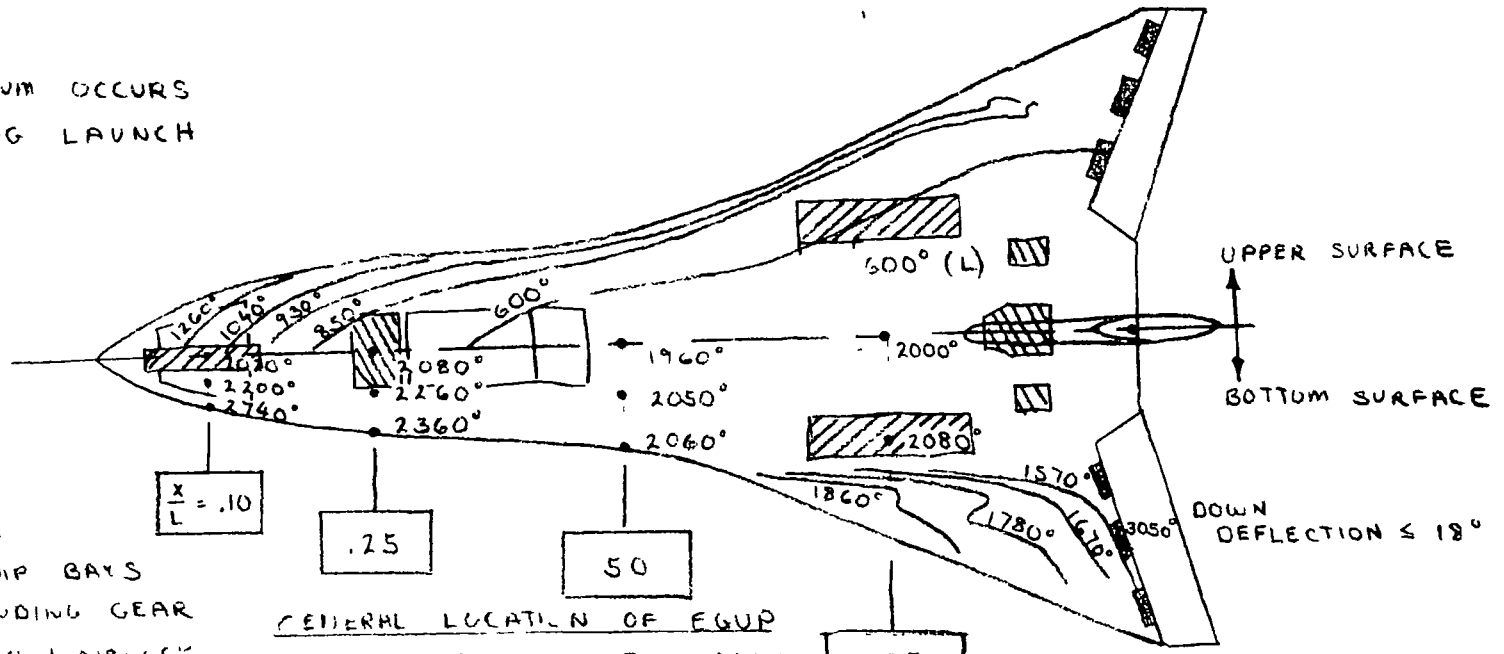
WEIGHT SUBSTANTIATION

HIGH CROSSRANGE - MARK 1 DELTA ORBITER (DWG 007 OR 021)
MAXIMUM OUTER SKIN TEMPERATURES
$(L/D = 1.75)$ $\alpha_{NOM} = 22.5°$

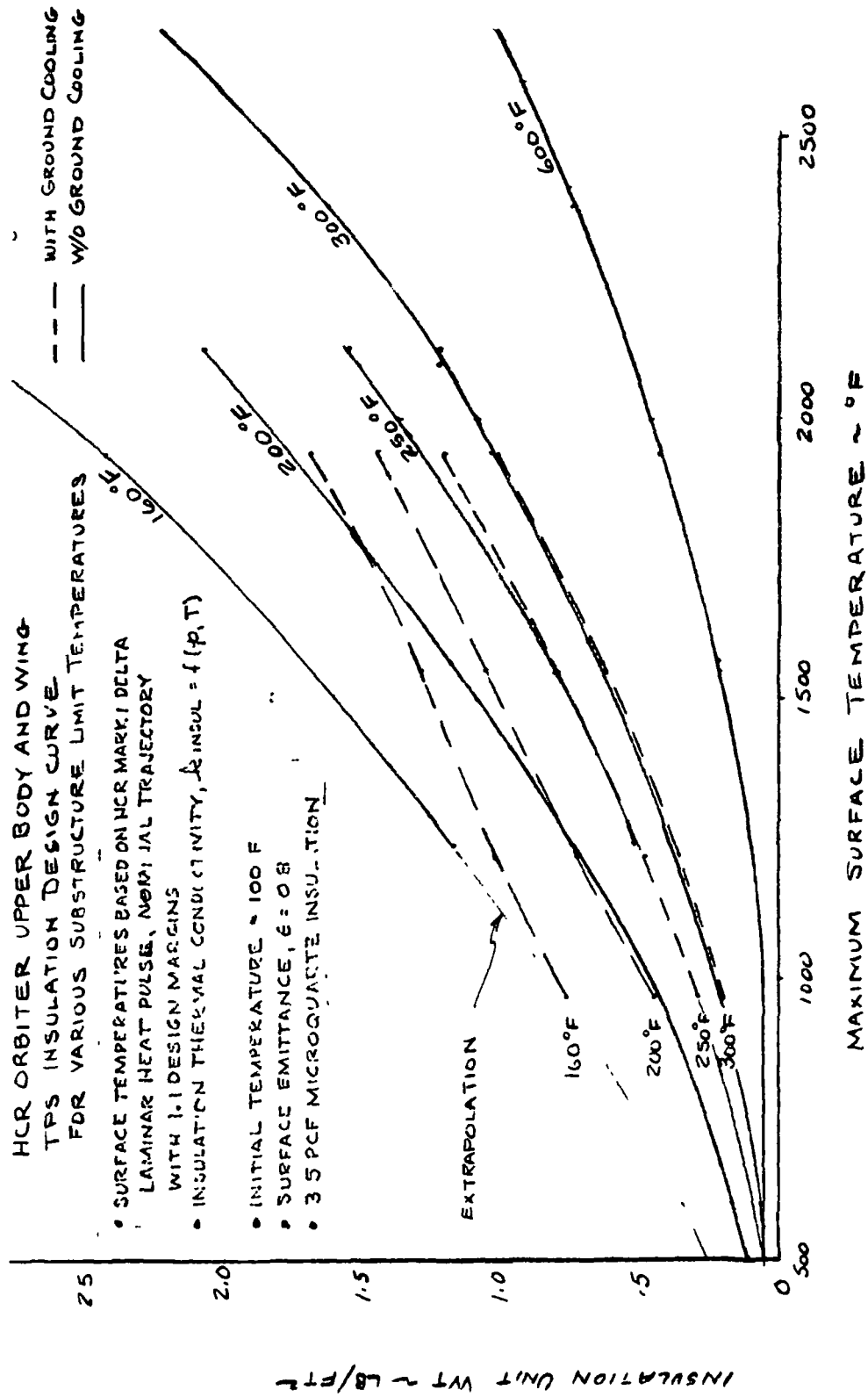
$q_{STAG} = 81$ BTU/FT²-SEC
$\ell = 1$ FT

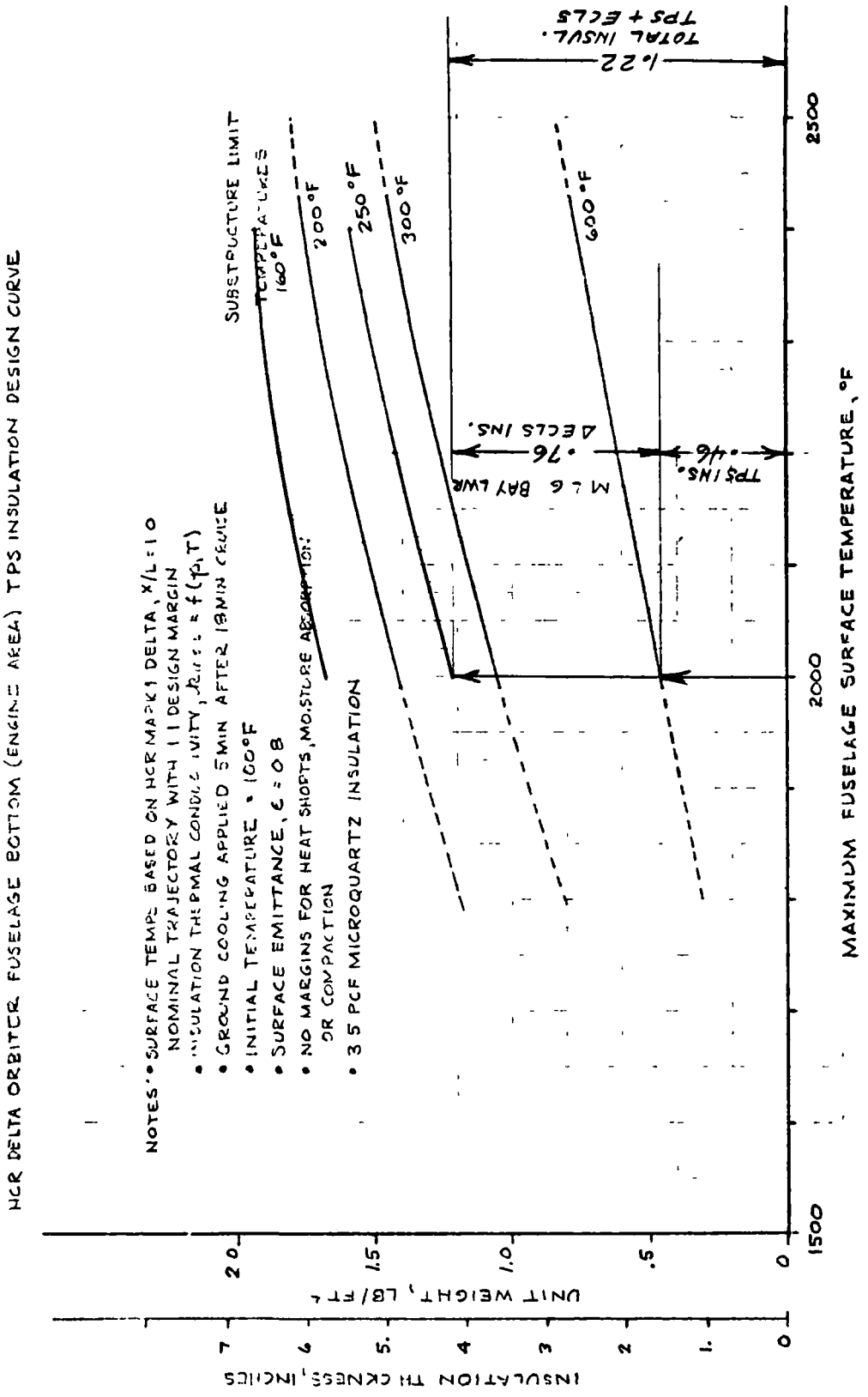


(L) MAXIMUM OCCURS DURING LAUNCH



WEIGHT SUBSTANTIATION




NCR DELTA ORBITER FUSELAGE BOTTOM (ENGINE AREA) TPS INSULATION DESIGN CURVE
NOTES:
• SURFACE TEMPS BASED ON NCR MARK I DELTA, X/L = 1.0
NOMINAL TRAJECTORY WITH 1.1 DESIGN MARGIN
• INSULATION THERMAL CONDUCTIVITY, k = f(ρ,T)
• GROUND COOLING APPLIED 5MIN AFTER 18MIN CRUISE
• INITIAL TEMPERATURE = 100°F
• SURFACE EMITTANCE, ε = 0.8
• NO MARGINS FOR HEAT SHORTS, MOISTURE ABSORPTION OR COMPACTION
• 3.5 PCF MICROQUARTZ INSULATION
SUBSTRUCTURE LIMIT TEMPERATURES
160°F
200°F
250°F
300°F
600°F
TOTAL INSUL. TPS + ECLS
1.22
M 1.6 BAY LWR
.76
ECLS INS.
.46
TPS INS.
INSULATION THICKNESS, INCHES
UNIT WEIGHT, LB/FT²
MAXIMUM FUSELAGE SURFACE TEMPERATURE, °F
0
1.
2.
3.
4.
5.
6.
7
0
.5
1.0
1.5
2.0
1500
2000
2500

WEIGHT SUMMARIZATION

E.C.L.S UNIT WEIGHT CALCULATION

REGION	(1) OML TEMP MAX. °F	(2) SUBSTR LIMIT TEMP °F	(3) MAX DESIGN TEMP °F	(4) INSUL REQ'D (1) to (2) LB/FT²	(5) INSUL REQ'D (1) to (3) LB/FT²	(6) Δ INSUL (5) - (4) LB/FT²	(7) INSUL BAGS LB/FT²	(8) INSTALLATION UNIT WEIGHT LB/FT²	(9) INSTALLATION WEIGHT BLOCKS LB/FT²	TOTAL UNIT WEIGHT (6)+(7)+(8)+(9) LB/FT²
CABIN WALL	600	300	160	0.06	0.35	0.29	0.02	0.045	0.055	0.41
PLUCK	600	300	160	0.06	0.35	0.29	0.02	0.045	0.055	0.41
[illegible] COOLING TUNNEL	1040	300	200	0.24	0.50	0.26	0.02	0.045	0.055	0.376
[illegible] G BAY	2020	300	250	1.07	1.24	0.17	0.015	0.045	0.055	0.285
[illegible] C BAY LWR UPR.	2000 600	600 600	250 250	0.46 —	1.22 0.10	0.76 0.10	0.132 0.106	0.045 0.045	0.055 0.055	0.992 0.306
TAIL OUTBD ACTS - LWR. SURF	1600	600	250	0.24	0.85	0.61	0.125**	0.045	0.055	0.835
TAIL OUTBD ACTS UPR. SURF.	600	600	250	—	0.10	0.10	0.106**	0.045	0.055	0.306
TAIL ACTS	1400	600	250	0.16	0.65	0.49	0.12**	0.045	0.055	0.71
[illegible] L G EQUIPMENT BAY	2020	300	200	1.07	1.43	0.36	0.02	0.045	0.055	0.48
FWD AVIONICS EQUIPMENT BAY	850	300	200	0.17	0.34	0.17	0.02	0.045	0.055	0.29
AFT AVIONICS EQUIPMENT BAY	600	300	200	0.06	0.17	0.11	0.02	0.045	0.055	0.23
HYDRAULICS BAY	600	300	200	0.06	0.17	0.11	0.02	0.045	0.055	0.23
SPEED BRAKES	600	300	250	0.06	0.10	0.04	0.02	0.045	0.055	0.16
CRUISE ENG LWR UPR.	2000 600	600 600	250 250	0.46 —	1.22 0.10	0.76 0.10	0.132 0.106	0.045 0.045	0.055 0.055	0.992 0.306

** (5) SIDED 4 MIL TITANIUM BAGS. ALL OTHER (5) SIDED 2 MIL KAPTON BAGS

REFERENCES & DATA SOURCES

REFERENCE NO.	PART NAME	VENDOR &/OR PROJECT	PART NO.
1.	NITROGEN STORAGE TANK	HAMILTON STANDARD (REF PAGE 2.14-51)	MDAC-SSM -0016
2.	NITROGEN FILL VALVE & FILTER	AMINCO UNION	
3.	H.P. S/O VALVE	AIRSEARCH/GEMINI	52-83700-7
4.	REGULATOR & RELIEF VALVE	AIRSEARCH/GEMINI	52-83700-57
5.	CHECK VALVE	AIRSEARCH/GEMINI	52-83700-15 (CHG. TO STEEL)
6	MANUAL S/O VALVE	AIRSEARCH/GEMINI	52-83700-3
7.	OXYGEN STORAGE TANK	HAMILTON STANDARD (REF. PAGE 2.14-51)	MDAC-SSM -0016
8.	OXYGEN FILL VALVE & FILTER	AMINCO UNION	
9.	TEE WITH CAP		AN824-8
10.	OXYGEN MASK	CREW SYSTEMS DIV. OF NASA MSC/SKYLAB	CSD651-400 -07
11.	NITROGEN CONTROL VALVE	SKYLAB	61C830086
12.	PLUMBING & FITTINGS	EST. BASED ON GEMINI	2 LB/TANK
13.	CIRCUITRY & MISC	EST. BASED ON GEMINI	.25 LB/PICK-UP
14	MOUNTING STR.	FOR EMPIRICAL ESTIMATION METHOD SEE PAGE 2.13-39 & -40	
15.	SELECTOR VALVE	AIRSEARCH/GEMINI	52-83700-2055

REFERENCES & DATA SOURCES - CONT.

REFERENCE NO.	PART NAME	VENDOR &/OR PROJECT	PART NO.
16.	PRESSURE REGULATOR MODULE	SKYLAB	61C830083
17.	PO_2 SENSOR	SKYLAB	61B830055
18.	AMPLIFIER & CONTROL	SKYLAB	61B830019
19.	PRESSURE EQUILIZATION VALVE & GAUGES ASSY	HAMILTON STANDARD (REF PAGE 2.14-53)	MDAC-SSM -0022
20	CABIN PRESSURE RELIEF VALVE	HAMILTON STANDARD (REF PAGE 2.14-52)	MDAC-SSM -0017
21.	PLUMBINGS & FITTINGS	EST. BASED ON GEMINI	5 LB/SYS.
22.	LITHIUM HYDROXIDE PKG.	HAMILTON STANDARD (REF PAGE 2.14-50)	MDAC-SSM -0010
23.	LITHIUM HYDROXIDE CART.	HAMILTON STANDARD (REF PAGE 2.14-50)	MDAC-SSM -0011
24.	VENTILATION FAN MODULE	HAMILTON STANDARD (REF. PAGE 2.14-50)	MDAC-SSM -0012
25.	CONDENSING H. X.	HAMILTON STANDARD (REF PAGE 2.14-53)	MDAC-SSM -0025
26.	CONTROL VALVE MANUAL	AIRESEARCH/GEMINI	52-83700-2055 (EST 2 LB)
27.	PCO_2 SENSOR	SKYLAB	61B880055
28	CABIN H.X.	HAMILTON STANDARD (REF PAGE 2.14-51)	MDAC-SSM -0013
29.	WINDOW DEFOGGER H.X.	HAMILTON STANDARD (REF. PAGE 2.14-54)	MDAC-SSM -0028

REFERENCES & DATA SOURCES - CONT.

REFERENCE NO	PART NAME	VENDOR &/OR PROJECT	PART NO.
30.	CABIN AIR INLET DUCTS	SEE PG. 2.14-36	
31.	CABIN AIR OUTLET DUCTS	SEE PG. 2.14-36	
32	POWER CIRCUITRY	SEE PG. 2.13-3	
33.	COOLANT PUMP PACKAGE	HAMILTON STANDARD (REF. PAGE 2.14-52)	MDAC-SSM -0018
34.	RESERVOIR	HAMILTON STANDARD (REF PAGE 2.14-50)	MDAC-SSM -0009
35.	FILTER & RELIEF VALVE	AIRSEARCH/GEMINI	52-83771 (CHG. TO STEEL)
36.	VENT VALVE	AIRSEARCH/GEMINI	52-83700-3
37.	CONDENSATE WATER SUBSYSTEM	HAMILTON STANDARD (REF PAGE 2.14-53)	MDAC-SSM -0024
38.	INTERFACE HEAT EXCHANGER	HAMILTON STANDARD (REF PAGE 2.14-51)	MDAC-SSM -0014
39	CABIN LOOP PLUMBING	MDAC MEMO NO. SSPI-E450-588 FOR LINE SIZE ANALYSIS	
40	EQUIPMENT LOOP PLUMBING	MDAC MEMO NO. SSPI-E450-576 FOR LINE SIZE ANALYSIS	
41.	GROUND COOLING H X.	HAMILTON STANDARD (REF PAGE 2.14-54)	MDAC-SSM -0026

REFERENCES & DATA SOURCES - CONT.

REFERENCE NO.	PART NAME	VENDOR & /OR PROJECT	PART NO.
42	CRYOGENIC HEAT EXCHANGER	HAMILTON STANDARD (REF. PAGE 2.14-54)	MDAC-SSM -0027
43.	PRODUCT WATER ACCUMULATOR MODULE	HAMILTON STANDARD (REF. PAGE 2.14-52)	MDAC-SSM -0020
44.	DUMP VALVE MODULE	HAMILTON STANDARD (REF. PAGE 2.14-53)	MDAC-SSM -0023
45.	PRESSURE RELIEF VALVE	AIRSEARCH/GEMINI.	52-83700 -2011
46.	CHECK VALVE	AIRSEARCH/GEMINI	52-83700 -2049
47.	WASTE MANAGEMENT SYSTEM	DESIGN NOTE	O-EAST-ECLS-012 ECT.
48	RADIATOR EFFECTIVE AREA REQUIREMENTS ARE DISCUSSED IN DETAIL IN MDAC MEMO NO. SSPI-E450-576.		
49.	FIRE EXTINGUISHERS	WALTER KIDDE	DWG. NO. MS891083

2.15	Personnel Provisions		430 Lb	
				Page No.
	Crew Seats (2 - Command Pilot & Pilot)		[159]	2.15-2
	Seats		(153)	
	Safety Belt		(4)	
	Harness Reel		(2)	
	Fixed Life Support Equipment		[130]	
	Food & Utensil Stowage		(40)	2.15-8
	Water Storage Tank		(20)	2.15-8
	Galley Equipment		(70)	2.15-2
	Oven	10		
	Freezer	50		
	Water Heater	5		
	Water Cooler	5		
	Emergency Equipment		[30]	2.15-9
	Furnishings		[91]	
	Privacy Curtain		(3)	2.15-9
	Partitions - Non-structural		(12)	2.15-8
	Equipment Stowage Provisions		(76)	2.15-8
	Lockers	27		
	Pressure Suit Stowage	17		
	Equipment Cabinets	32		
	Contingency (5%)		[20]	

PERSONNEL PROVISIONS GROUP WEIGHT SUMMARY

15 PERSONNEL PROVISIONS		430
SEATS/RESTRAINT SYS (NO = 2)	159	
FIXED LIFE SUPPORT EQUIPMENT	130	
EMERGENCY EQUIPMENT	30	
CARGO HANDLING	N/A	
FURNISHINGS	91	
CONTINGENCY	20	

The Personnel Provisions Group consists of the fixed equipment required for personnel safety, comfort and survival. The equipment required for atmosphere and temperature control is part of the Environmental Control/Life Support System.

The weights in this section are estimated from either simplified non-stress analyses or empirical methods. The weight carried for crew members seats is the actual weight of a DC-10 type pilot seat.

WEIGHT SUBSTANTIATION DATA

SEAT/RESTRAINT SYSTEM — 159 LB.

DC-10 PILOT SEAT	76.57 LB
DC-10 BELT SYSTEM	3.00 LB

GALLEY EQUIPMENT — 70 LB.

ITEM	VOLUME CU.FT.	WEIGHT LB	NOTE
OVEN	0.5	10	1
FREEZER	2.0	50.	1
WATER HEATER	0.6	5	2
WATER COOLER	0.7	5.	2

NOTES:
1 WEIGHT & VOLUME DATA FROM FAIRCHILD HILLER DWG NO MS004G7611.
2 WEIGHT & VOLUME DATA FROM BIOASTRONAUTICS DATA BOOK, NASA SP-3006-1964.

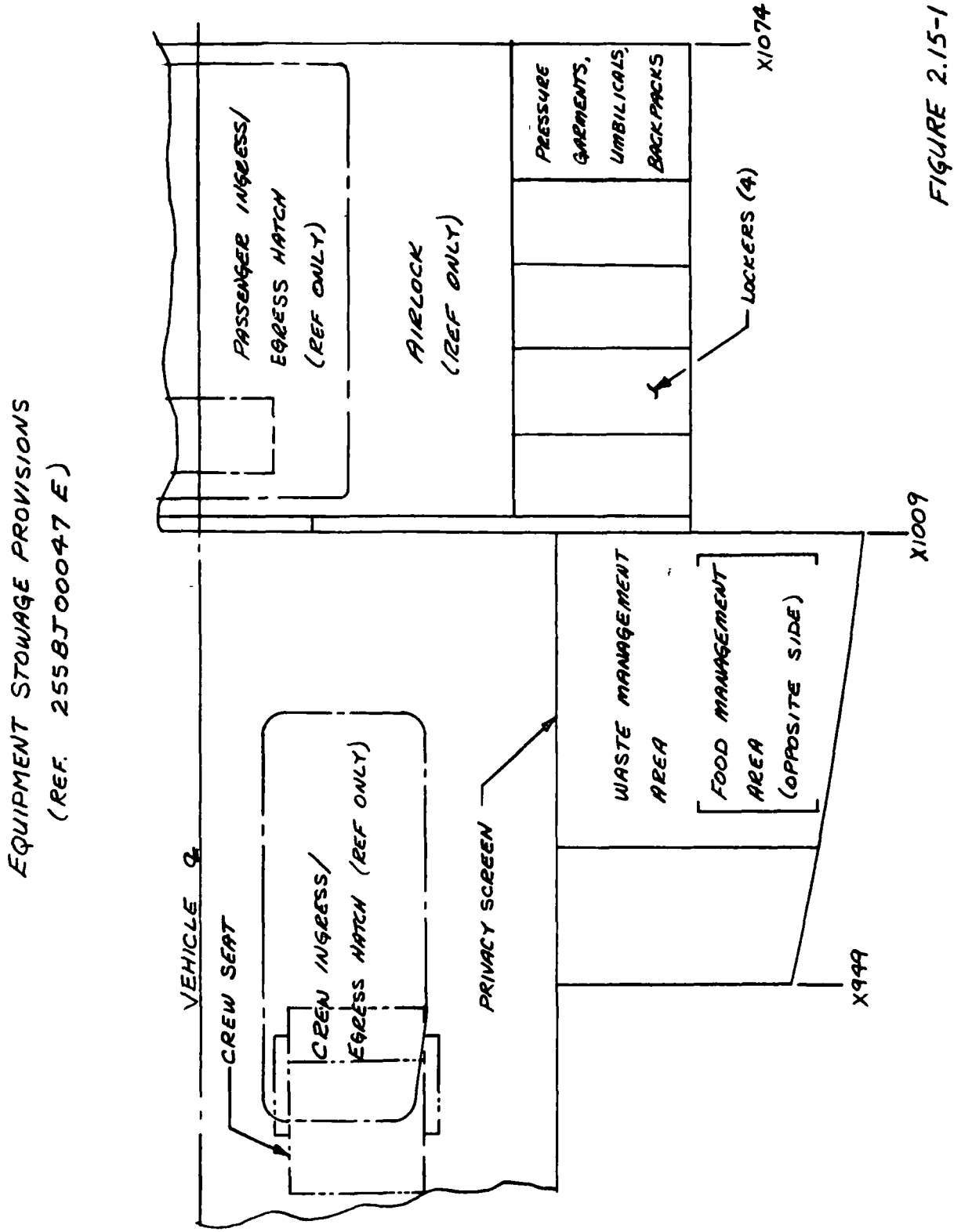

EQUIPMENT STOWAGE PROVISIONS
(REF. 2558T00047 E)
VEHICLE
CREW SEAT
CREW INGRESS/
EGRESS HATCH (REF ONLY)
PRIVACY SCREEN
WASTE MANAGEMENT
AREA
FOOD MANAGEMENT
AREA
(OPPOSITE SIDE)
PASSENGER INGRESS/
EGRESS HATCH
(REF ONLY)
AIRLOCK
(REF ONLY)
PRESSURE
GARMENTS,
UMBILICALS,
BACKPACKS
LOCKERS (4)
X1074
X1009
X949

FIGURE 2.15-1

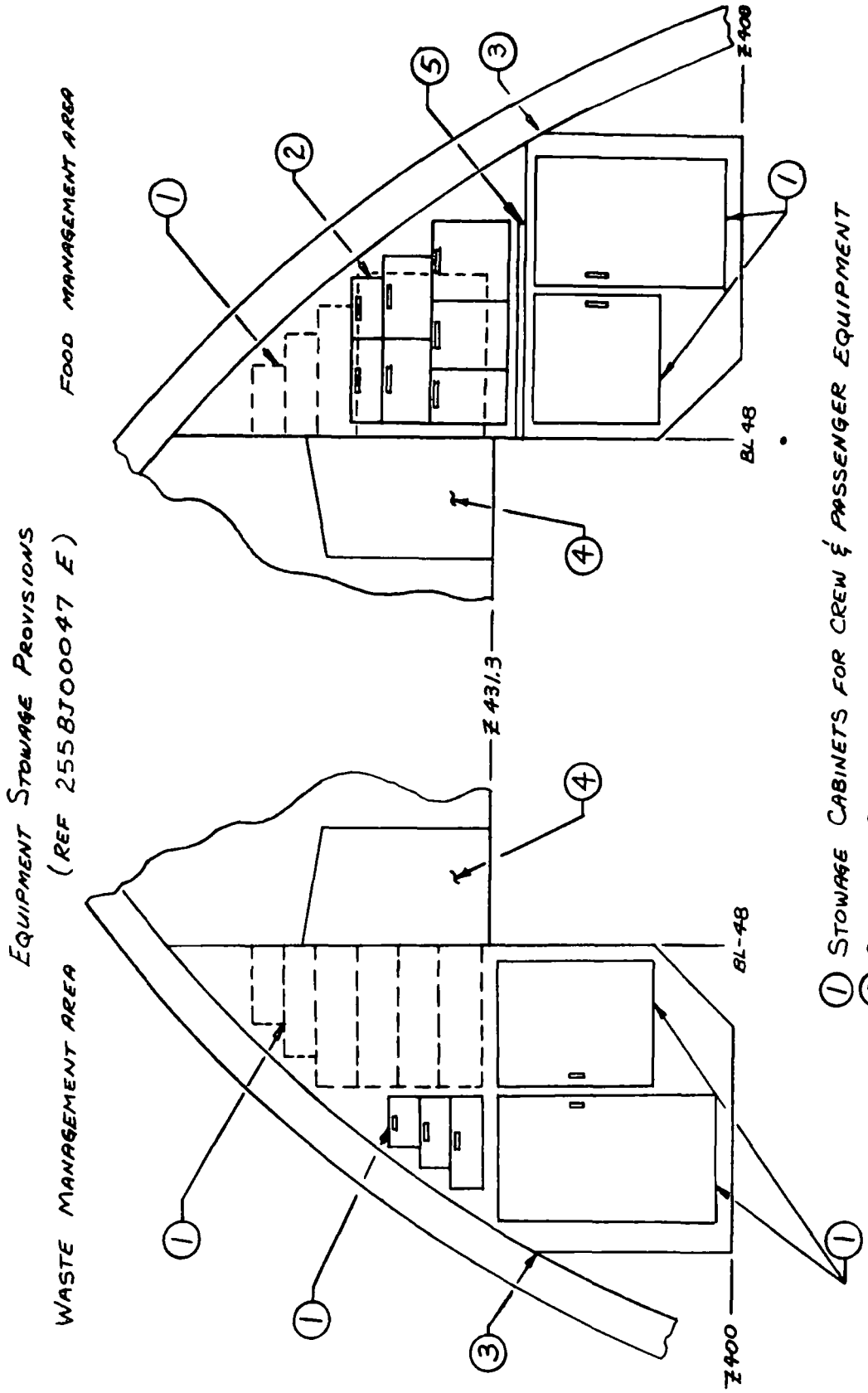

EQUIPMENT STOWAGE PROVISIONS
(REF 2558J000047 E)
WASTE MANAGEMENT AREA
FOOD MANAGEMENT AREA
Z 400
BL 48
Z 431.3
BL 48
Z 400
① STOWAGE CABINETS FOR CREW & PASSENGER EQUIPMENT
② STOWAGE CABINETS FOR FOOD PROVISIONS
③ MAIN LONGERON (REF. ONLY)
④ SIDE CONSOLE (REF ONLY)
⑤ WORKSHELF

FIGURE 2.15-2

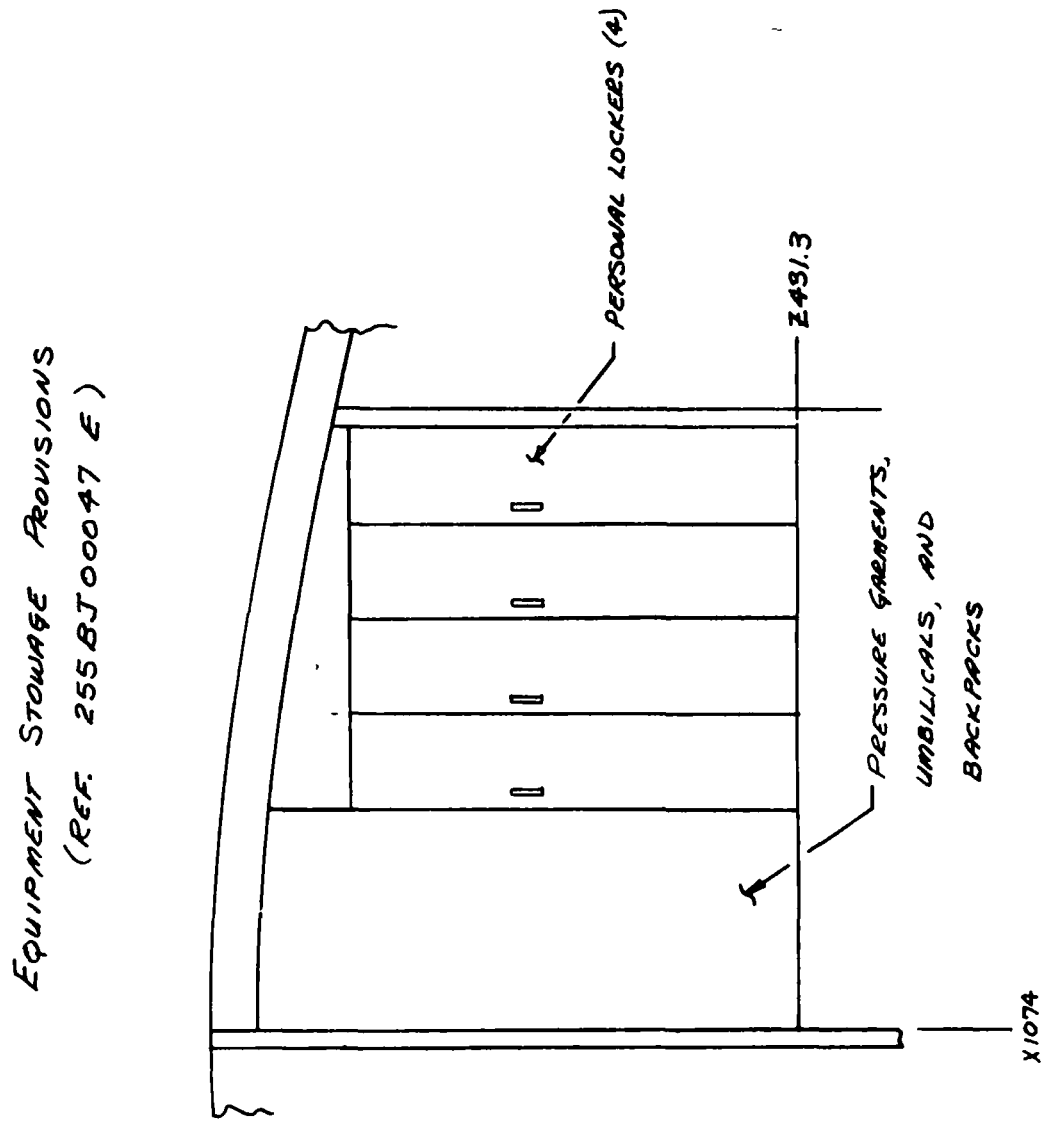
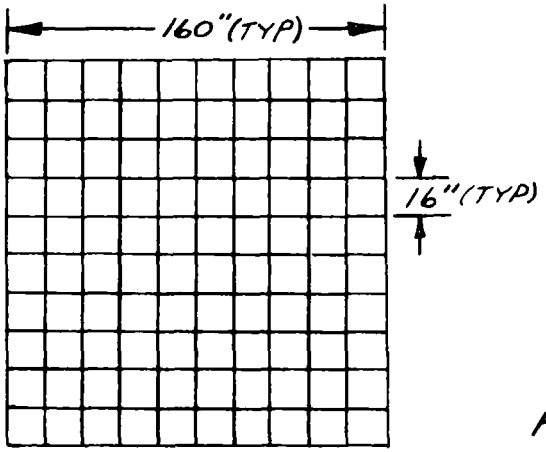
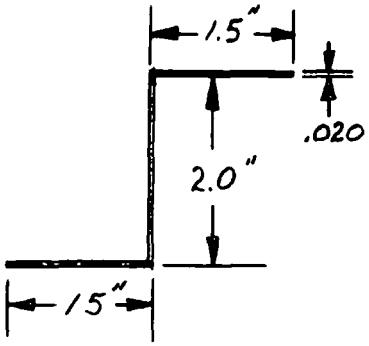

EQUIPMENT STOWAGE PROVISIONS
(REF. 255BJ00047 E)
PERSONAL LOCKERS (4)
Z431.3
PRESSURE GARMENTS,
UMBILICALS, AND
BACKPACKS
X1074

FIGURE 2.15-3

ESTIMATED UNIT WEIGHT OF NON-STRUCTURAL PARTITIONS AND STOWAGE CABINETS

ASSUME A 160" x 160" PANEL WITH 16" STIFFENER SPACING





ASSUMED STIFFENER SECTION

ALL PARTS .020 ALUMINUM

$$\text{STIFFENER WEIGHT} = 22 \times (1.5 + 2.0 + 1.5) \times .020 \times 160 \times .100$$
$$= 352 \text{ LB}$$

$$\text{SKIN WEIGHT} = 160 \times 160 \times .020 \times .100$$
$$= 512 \text{ LB.}$$

$$\text{AVERAGE UNIT WEIGHT} = \frac{352 + 512}{160 \times 160} \frac{\text{LB}}{\text{IN}^2} \times 144 \frac{\text{IN}^2}{\text{FT}^2}$$

$$= .486 \text{ LB/FT}^2$$

ROUND-OFF AND USE $\boxed{.5 \text{ LB/FT}^2}$

STOWAGE CABINET AND PARTITION SURFACE AREAS

WASTE MANAGEMENT AREA (WM)

EQUIP STOWAGE CABINETS	64	SQ.FT.
PARTITIONS	8	SQ FT.
PRIVACY CURTAIN	13	SQ.FT.

FOOD MANAGEMENT AREA (FM)

FOOD STOWAGE CABINETS	20	SQ.FT.
UTENSIL STOWAGE CABINETS	54	SQ.FT.
PARTITIONS	16	SQ FT.
WORKSHELF	3	SQ.FT.

AIRLOCK (AL)

LOCKERS	54	SQ.FT.
PRESSURE SUIT STOWAGE	34	SQ.FT.

CALCULATION OF STOWAGE CABINET & PARTITION WEIGHT

ITEM	LOCATION	AREA FT^2	UNIT WT. PSF	WEIGHT LB.
FOOD CABINETS	FM	20.	.5	10.
UTENSIL CABINETS	FM	54.	5	27.
WORKSHELF	FM	3.	1.*	3.
FOOD & UTENSIL STOWAGE				(40)
PARTITIONS	WM	8.	.5	4.
PARTITIONS	FM	16.	.5	8.
PARTITIONS-NON-STRUCTURAL				(12)
LOCKERS	AL	54	.5	27.
PRESS. SUIT STOWAGE	AL	34	.5	17.
EQUIPMENT CABINETS	WM	64	.5	32.
EQUIPMENT STOWAGE PROVISIONS				(76)

* HIGHER UNIT WEIGHT DUE TO HIGHER LOADING AND TWO CLOSED FACES.

WATER STORAGE TANK ** 20 LB.

** WEIGHT DATA REF HAMILTON STANDARD DWG. NO MDAC-SSM-0020
H_2O QUANTITY ON BOARD AT LAUNCH 25 LB. SEE SECT. 2.25.

CALCULATION OF PRIVACY CURTAIN WEIGHT

CURTAIN

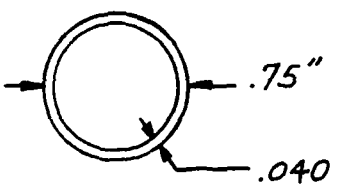
MATERIAL - RUBBER IMPREGNATED FIBERGLASS CLOTH

UNIT WEIGHT - .08 LB/FT^2

CURTAIN WEIGHT = 13 FT^2 × .08 LB/FT^2 = 1.04 LB.

SUPPORT RODS

MATERIAL - ALUMINUM TUBING



UNIT WEIGHT = $\left[\pi/4 \times (.75)^2 - \pi/4 \times (.75-.08)^2\right] \times .100$ = .019 LB/IN

ROD WEIGHT = 2 × 42 IN × .019 LB/IN = 1.60 LB.

ROD SUPPORTS (ESTIMATED)	.20 LB.
ATTACH RINGS (ESTIMATED)	.15 LB.
TOTAL CURTAIN WEIGHT	2.99 LB.

EMERGENCY EQUIPMENT

EQUIPMENT WEIGHT (ESTIMATED)	30 LB

		Weight	Page No.
2.18	Growth/Uncertainty	25363 Lb	2.18-2

2.18 Growth/Uncertainty

The Growth/Uncertainty is the dependent variable in our weight derivation. An allowable orbiter burnout weight is established based upon ascent trajectory performance for the total system on the polar mission using minimum specific impulse. Then the Growth/Uncertainty is derived by subtracting all system and applicable fluid weight from the burnout weight. These data are shown below.

	Easterly	Resupply	Polar
Orbiter B.O.	332224	317593	302519
Wt. Less G/U	306861	295875	279433
G/U	25363	21718	23086

2.20 Personnel	626 Lb	Page No.
Crew	[433]	
Crew Members (2)	(392)	2.20-2
Constant Wear Garmets (2)	(2)	2.20-2
Headsets (2)	(1)	2.20-2
Helmets (2)	(12)	2.20-2
Pressure Suits (2)	(26)	2.20-2
Personal Gear	[53]	2.20-3
Personal Equipment	(12)	2.20-3
Protective Garmets	(25)	2.20-3
Hygenic Equipment	(16)	2.20-3
Life Support	[115]	2.20-4
Food & Packaging	(59)	2.20-4
Recreation Equipment	(3)	2.20-4
Medical and First Aid	(8)	2.20-4
Survival Kit	(45)	2.20-4
Accessories	[25]	2.20-4

PERSONNEL GROUP WEIGHT SUMMARY

20 PERSONNEL	NO	MAN	GARMENTS	HELMET	PRESS SUIT	ACCESSORIES		626
CREW	(2)	392	2	12	26	1	433	
PASSENGER	(0)	—	—	—	—	—	—	
PERSONEL GEAR/ACCESSORIES							78	
LIFE SUPPORT							115	
FOOD						59		
EQUIPMENT – PORTABLE						56		

The Personnel Group consists of the crew and all of their portable personal gear and survival kits. The weights for the crew members were obtained from USN(NAEC) ACEL-533-October 1965. The pressure suit weights were obtained from AiResearch Report No. 70-6053, 13 February 1970. The remainder of the equipment weights were obtained from NASA letter No. CF31-716-02, 4 February 1971.

WEIGHT SUBSTANTIATION DATA

CREW — 433 LB

ITEM	NO	UNIT WT	WEIGHT	NOTE
CREW MEMBERS	2	195.74	391.48	1
GARMENTS	2	.98	1.96	2
HELMET	2	5 66	11.32	3
PRESS SUIT	2	13	26.	4
HEADSETS	2	.6	1.2	2
ROUNDOFF			1.04	

NOTES
1. DATA FROM USN(NAEC) ACEL-533-OCTOBER 1965.
2. DATA FROM NASA LETTER NO CF31-71L-02, 4 FEBRUARY 1971.
3. NASA GEMINI G4-C TYPE HELMETS
4. DATA FROM AIREARCH MANUFACTURING CO REPORT NO. 70-6053, FINAL REPORT ON THE INTRAVEHICULAR ACTIVITY SPACE SUIT, 13 FEBRUARY 1970.

WEIGHT SUBSTANTIATION DATA*

ITEM	NO REQ'D	UNIT WT LB	WEIGHT LB
HEADSETS**	2	.60	1.20
SUNGLASSES	3	.06	.18
CHRONOMETER	2	.13	.26
PILLOW	2	.25	.50
PILLOW CASES	2	.10	.20
BLANKET	2	3.70	7.40
PERS. PREFERENCE KIT	2	1.00	2.00
PERSONAL EQUIPMENT			(11.74)
CONST. WEAR GAMENTS**	8	.98	7.84
COVERALLS	4	4.30	17.20
PROTECTIVE GARMENTS			(25.04)
PERSONAL HYGIENE KIT	2.00 LB MIN + .17 LB/DAY		6.38
BARFBAGS	8	.10	.80
TISSUES	4	1.40	5.60
TOWELS	14	.10	1.40
FECAL COLLECT BAG	4	.20	.80
URINE COLLECT. BAG	4	.32	1.28
HYGENIC EQUIPMENT			(16.26)
PERSONAL GEAR			53.04

* DATA FROM NASA LETTER NO CF31-71L-02, 4 FEBRUARY 1971.
** SPARES ONLY.

WEIGHT SUBSTANTIATION DATA*

ITEM	NO REQ'D	UNIT WT	WEIGHT
		LB	LB
FOOD & PACKAGING	14**	4.2**	(58.8)
EXERCISER	2	1.40	2.80
RECREATION EQUIPMENT			(2.80)
BIOINSTRUMENTATION	3***	1.10	3.80
MEDICAL KIT	2.00 LB + .17 LB/DAY		3.19
RADIATION DOSIMETERS	3	.40	1.20
MEDICAL & FIRST AID			(8.19)
LIFE VESTS	2	2.40	4.80
SURVIVAL GEAR	1	20.00	20.00
LIFE RAFT	1	20.00	20.00
SURVIVAL KIT			(44.80)
LIFE SUPPORT			114.59
SCISSORS	2	.53	1.06
PENCILS	6	.05	.30
PENLIGHT	3	.34	1.02
UTILITY KIT	2	2.00	4.00
FLIGHT DATA FILE	10 LB + .5 LB/DAY		13.50
BINOCULARS	1	1.20	1.20
PORTABLE FLOODLIGHT	1	4.00	4.00
ACCESSORIES			25.08

* DATA FROM NASA LETTER NO. CF31-71L-02, 4 FEBRUARY 1971.
** ON A MAN-DAY BASIS
*** THREE FULL SETS PLUS SPARE ELECTRODES.

		Weight	Page
2.21	Cargo	65000 lb	2.21-2

2.21 Cargo

Required cargo for the missions is shown below:

	Easterly	Polar	Resupply
Cargo	65000	40000	25000

2.23 Residual Fluids	4001 Lb.	
		Page No.
Ascent Propulsion	737	2.23-1
Cruise Propulsion	0	2.23-1
Auxiliary Propulsion	1430	2.23-1
ECS	621	2.23-1
Hydraulic	1087	2.23-1
Misc.	126	2.23-1

2.23 Residual Fluids

Residual fluids consist of propellant and service items remaining in a subsystem which are not usable. Unusable fluids which are dumped prior to landing are coded to inflight loss.

All auxiliary propulsion tank, line and accumulator residuals are included as maneuver residuals; even though, attitude control, ECS, EPS, and hydraulic system (APU) liquid hydrogen and liquid oxygen are included in these tanks. The maneuver system is the primary contributor to the tank size requirements.

RESIDUAL FLUIDS

SUMMARY

	EASTERLY	RESUPPLY	POLAR
ASCENT	737	737	737
CRUISE	0	204	0
MANEUVER & ATTITUDE	1430	1430	1430
ECS	621	621	621
EPS	INCLUDED	IN MANEUVER TK	
HYDRAULIC	1087	1087	1087
MISC.	126	126	126
TOTAL	4001	4205	4001

ASCENT (SEE SECTION 2.27)	(737)
GOX IN LOX TANKS, LINES & ENG	614
GH2 IN LH2 TANKS, LINES & ENG	115
He IN PNEUMATIC TANKS, LINES, & ACCUMULATORS	8
CRUISE (SEE SECTION 2.28)	(204)
TRAPPED JP IN TANK, LINES & VALVES	180
ENGINE LUBRICATION OIL (4 ENGINES)	24
MANEUVER & ATTITUDE CONTROL (SEE SECT 2.29)	(1430)
TRAPPED HYDROGEN	551
TRAPPED OXYGEN	793
TRAPPED HELIUM – START TANKS & He STORAGE TK.	86
ECS (SEE SECTION 2.14)	(621)
FREON – COOLANT LOOP (INCL RADIATOR)	435
WATER – CABIN COOLANT LOOP	96
OXYGEN TRAPPED IN LiOH CANISTER (AT END OF MISSION)	26
OXYGEN – UNUSABLE IN EMERGENCY TANK	1
OXYGEN – IN CABIN	15
N_2 – IN CABIN	44
N_2 – UNUSABLE IN TANK	4
HYDRAULIC (SEE SECTION 2.11)	(1087)
HYDRAULIC OIL	1087
MISC	(126)
MAIN LANDING GEAR SHOCK STRUT OIL	84
NOSE LANDING GEAR SHOCK STRUT OIL	42

NOTE:
SEE FLUID SUMMARY SECTION 3.3

2.25 Reserve Fluids	13118 Lb.	
		Page No.
Ascent Propulsion	6486	2.25-1
Cruise Propulsion	0	2.25-1
Maneuver	4720	2.25-1
Attitude Control	1662	2.25-1
ECS	102	2.25-1
Hydraulic	148	2.25-1

2.25 Reserve Fluids

The reserve fluids are usable fluids carried in excess of that required to perform the nominal mission(s) assuming nominal performance and a nominal mission profile. Extra fluids carried to provide for emergencies and abort are included here.

RESERVE FLUIDS

SUMMARY

	EASTERLY	REJUPPLY	POLAR
ASCENT	6486	6309	6184
CRUISE	0	2280	0
MANEUVER	4720	4118	8082
ATTITUDE CONTROL	1662	1662	1662
ECS	102	102	102
EPS	0	0	0
HYDRAULIC	148	148	148
TOTAL	13118	14619	16178
ASCENT	(6486)	(6309)	(6184)
FPR –LOX } DUMPED IF NOT USED	5543	5391	5284
–LH2 } DUMPED IF NOT USED	924	899	881
He – STAGE PNEUMATICS	19	19	19
CRUISE	(0)	(2280)	(0)
JP-4 (GO AROUND FUEL)		2280,	
MANEUVER (SEE SECTION 2.29)	(4720	X 4118	X 8082)
HYDROGEN	738	693	654
OXYGEN	3691	3425	3267
OXYGEN (TO PROVIDE CORRECT MIXTURE RATIO FOR ABORT)	291	0	4161
ATTITUDE CONTROL (SEE SECT. 2.29)	(1662	X 1662	X 1662)
ON-ORBIT			
HYDROGEN			146
OXYGEN			221
ENTRY			
HYDROGEN			516
OXYGEN			779
ECS (SEE SECT. 2.14)	(102)	(102)	(102)
WATER			65
OXYGEN – EMERGENCY SUPPLY			16
N_2			10
OXYGEN – MAIN SUPPLY (AUX. SYS. TK)			11
HYDRAULIC (APU)	(148)	(148)	(148)
OXYGEN			66
HYDROGEN			82

2.26 Inflight Losses	9788 Lb.	
		Page No.
Ascent Propulsion	6467	2.26-1
Auxiliary Propulsion	1552	2.26-1
ECS	324	2.26-1
EPS	640	2.26-1
Hydraulic	805	2.26-1

2.26 Inflight Losses

Inflight losses are:

- o Propellants expended by APUs
- o Propellants expended for attitude control
- o Vented propellants and pressurization gas.
- o ECS fluids expended.
- o Main ascent startup, shutdown, dumped unusables, and on orbit vented propellants.

All auxiliary tank, line and accumulator losses are included as auxiliary propulsion system losses; even though, ECS, EPS and hydraulic (APU) propellants are included in these tanks.

INFLIGHT LOSSES

ASCENT			(6467)
START UP			1962
ENGINE CONTROL (PNEUMATIC)			20
SHUTDOWN			256
DUMPED UNUSABLE PROPELLANT			4133
ON-ORBIT BOILOFF THRU VENT SYS			96
AUXILIARY PROPULSION			(1552)
COMPARTMENT PURGE (13LB He)			13
ACCUMULATOR RECHARGE VENT (50 LB He, 6LB O_2, 32LB H_2)			88
COOLDOWN (20LB O_2, 40LB H_2)			60
ENGINE PURGE (102LB H_2)			102
BOILOFF	NOM. (1289.4)	ABORT (208.1)	1289
H_2 TURBOPUMP COOLING	90.7	1.1	
H_2 OMS FEEDLINES	359.0	4.3	
ON-ORBIT BOILOFF			
TANK COOLING	270.0	3.2	
AUTOGENOUS PRESS	290.5	3.5	
ENTRY BOILOFF	160.0	160.0	
ASCENT BOILOFF	35.0	35.0	
TANK SUPPORT HEAT LEAKS	0.7	0.0	
ACPS FEEDLINES	83.5	1.0	
ECS			(324)
REPRESS & LEAKAGE (23LB O_2, 67LB N_2)			90
COOLING CRYOGEN (234LB H_2)			234
EPS			(640)
OXYGEN			569
HYDROGEN			71
HYDRAULIC (APU PROPELLANTS)			(805)
OXYGEN			359
HYDROGEN			446

INFLIGHT LOSSES

LOSS	FROM → LAUNCH IGNITION	IGNITION SHUTDOWN	SHUTDOWN INJECTION	INJECTION ON-ORBIT	ON-ORBIT PRE-RETRO	PRE-RETRO ENTRY	ENTRY LANDING	TOTAL
ASCENT	(1962)	(20)	(256)	(4133)	(96)			(6467)
LOX	1564		176	3788	61			5589
LH2	398		80	345	35			858
He		20						20
AUXILIARY PROPULSION		(35)			(1319)		(198)	(1552)
LOX					26			26
LH2		35			1268		160	1463
He					25		38	63
ECS					(324)			(324)
LH2					234			234
LOX					23			23
N2					67			67
EPS					(640)			(640)
LOX					569			569
LH2					71			71
HYDRAULIC (APU)		(132)					(636+37 / 352+21 / 284+16)	(805)
LH2		73						446
LOX		59						359

NOTE: SOME SIMPLIFING ASSUMPTIONS ARE INCLUDED IN THE ABOVE MISSION SEQUENCE.

2.27	Ascent Propellant	526257 Lb.	
			Page No.
	Main Ascent Propellant	(526257)	2.27-1
	Hydrogen	75180	3.3-1
	Oxygen	451077	3.3-1

2.27 Ascent Propellant

Minimum and maximum I_{SP} propellant loads for all three missions are listed. Flight performance reserves are included for reference only. FPR weight is carried in reserve fluids.

Page 2.27-3 shows the derivation of the minimum I_{SP} loading from tank and line volumes. For calculation convenience dumpable propellant, and unusable main tank propellants are included on this page.

COMPARISON OF NOMINAL AND MINIMUM I_{SP} PROPELLANT LOADINGS

ITEM	MINIMUM I_{SP}	NOMINAL I_{SP}	WEIGHT OFFLOADED
Polar Mission			
Orbiter			
Nominal Ascent Tank Prop.-Lb	534819	526559	8260
OMS Tank Fill-up Increment - Lb	22368	22368	0
Flight Performance Reserve - Lb	6225	6184	41
Total Usable Ascent Propellant - Lb	(563412)	(555111)	(8301)
Booster			
Total Usable Ascent Propellant - Lb	(3085081)	(3038600)	(46481)
Resupply Mission			
Orbiter			
Nominal Ascent Tank Prop. - Lb	534700	526434	8266
Flight Performance Reserve - Lb	6344	6309	35
Total Usable Ascent Propellant - Lb	(541044)	(532743)	(8301)
Booster			
Total Usable Ascent Propellant - Lb	(3085081)	(3038600)	(46481)
Easterly Mission			
Orbiter			
Nominal Ascent Tank Propellant - Lb	534519	526257	8262
Flight Performance Reserve - Lb	6525	6486	39
Total Usable Ascent Propellant - Lb	(541044)	(532743)	(8301)
Booster			
Total Usable Ascent Propellant - Lb	(3085081)	(3038600)	(46481)

Notes:
(1) Flight Performance Reserve equal to 1% of total ascent ΔV.
(2) Min. I_{SP} = 456 sec for Orbiter, 436 sec for Booster
(3) Nom. I_{SP} = 459 sec for Orbiter, 439 sec for Booster.
(4) 1962 lb of startup propellant is not included in Orbiter usable propellant.
(5) Propellant weights do not include 1% loading allowance.

MAIN PROPULSION FLUIDS & TANK SIZE SUMMARY	TOTAL	H_2	O_2
TOTAL MAIN TANK VOLUME	25458	18830	6628
INTERIOR VOLUME (INCLUDES 3% ULLAGE)	24973	18471	6502
NET MAIN TANK PROPELLANT VOLUME	24246	17933	6313
VOLUME OF FEED LINES AND ENGINES	425	53	372
TOTAL PROPELLANT VOLUME	24671	17986	6685
MAX. PROPELLANT LOAD (ρ_O=71.0; ρ_H=4.395)	553703	79048	474655
LESS: LOAD ALLOWANCE (1%)	-5483	-783	-4700
TOTAL LOADED (MIN. ISP)	548220	78265	469955
LESS: P.U. BIAS	-194	-194	0
PRESSURANT (LOX FOR GOX)	-825	-150	-675
UNUSABLE			
ENGINE	-1440	-80	-1360
FEED LINES	-366	-38	-328
TANK	-2133	-33	-2100
LOSSES			
START	-1962	-398	-1564
SHUTDOWN	-256	-80	-176
USEFUL PROPELLANT PLUS FPR (MIN. ISP)	541044	77292	463752
TOTAL LOADED LESS USEFUL PROP & FPR	7176	973	6203
LESS: LOSSES (ASCENT)	-2218	-478	-1740
PRESSURANT LOSS ON ORBIT & ENT	-96	-35	-61
PRESSURANT REMAINING AT LDG	-729	-115	-614
DUMPED PROPELLANT (NOT INCL. FPR)	4133	345	3788

2.28	Cruise Propellant	0	Lb.

		Page No.
Fuel for Approach and Landing	1140*	2.28-1

*Not included in Easterly or Polar Missions.

2.28 Cruise Propellant

Cruise fuel for the resupply mission is listed here. Ferry mission requirements are not addressed in this report.

CRUISE PROPELLANT

– RESUPPLY MISSION ONLY –

FUEL REQUIRED FOR APPROACH AND LANDING	=	1140 LB
FUEL REQUIRED FOR APPROACH, GO-AROUND AND LANDING	=	3420 LB
TOTAL USABLE FUEL REQUIRED	=	3420 LB
TRAPPED FUEL	=	180 LB
TOTAL LOADED		3600 LB

2.29 Auxiliary Propellant	17510 Lb.	
		Page No.
Maneuver Propellant	(15847)	3.3-1
Hydrogen	2780	2.29-1
Oxygen	13067	2.29-1
Attitude Control	(1663)	3.3-1
Hydrogen	367	2.29-1
Oxygen	1296	2.29-1

2.29 Auxiliary Propellant

The auxiliary propellant is the propellant loaded for attitude control and orbital maneuvers.

Page 2.29-2 is a summary of the attitude and maneuver propellant requirements by mission sequence and mission. Reserve propellants including excess oxidizer loaded to provide for abort are included on this page to provide a more complete summary. These reserves must be subtracted to determine the nominal load. Also see the fluids summaries in section 3.3.

Page 2.29-3 is a summary of all non-maneuver propellants which are loaded in the auxiliary tanks. A summary of the minimum fluid provisions which must be left after an abort to orbit is also included on this page.

Pages 2.29-4 thru 2.29-6 are the calculations of total tank load required for each mission. The larger value for fuel or oxidizer for the abort or nominal mission is used. The resupply mission load with it's large nominal maneuver requirement (1500 fps) is not affected by the abort requirements.

Page 2.29-7 shows the derivation (based on tank volume and auxilary tank load for other purposes) of the propellant capacity available for ascent burn of the OMS.

AUXILIARY PROPULSION LOADING SUMMARY			TOTAL	H_2	O_2
ACS ALL MISSIONS					
INJECTION TO ON ORBIT	NONE		0		
ON ORBIT TO PRE RETRO	1/2 50%		663	146	517
PRE RETRO TO ENTRY	NONE		0		
ENTRY TO BEGIN CRUISE	ENT: 50%		1000	221	779
RESERVE			1662	367	1295
TOTAL ACS			3325	734	2591
65K EASTERLY	ISP	ΔV			
INJECTION TO ON ORBIT	444	90	1993.	332.	1661.
ON ORBIT TO PRE RETRO			(8318.)	(1525.)	(6793.)
	379	100	2560.	565.	1995.
	444	260	5758.	960.	4798.
PRE RETRO TO ENTRY	444	250	5536.	923.	4613.
RESERVE	444	20	4429.	738.	3691.
EXCESS O_2			291.	0	291
TOTAL MANEUVER			20567	3518.	17049
25K RETURN					
INJECTION TO ON ORBIT	444	660	13529.	2255.	11274.
ON ORBIT TO PRE RETRO	379	180	4359.	962.	3397.
PRE RETRO TO ENTRY	444	460	9429.	1571..	7858.
RESERVE			(4118.)	(693.)	(3425.)
	379	5	121.	27	94.
	444	195	3997.	666	3331.
TOTAL MANEUVER			31435.	5481.	25954.
40K POLAR					
INJECTION TO ON ORBIT	444	90	1765.	294.	1471.
ON ORBIT TO PRE RETRO			(3693.)	(736.)	(2957.)
	379	100	2223.	491.	1732
	444	75	1470.	245.	1225
PRE RETRO TO ENTRY	444	250	4901.	817.	4084.
RESERVE	444	200	3921.	654.	3267.
EXCESS O_2			4161.	0.	4161.
TOTAL MANEUVER			18441.	2501.	15940.

AUXILIARY PROPULSION NON-MANEUVER PROPELLANTS	TOTAL	H_2	O_2
NOMINAL MISSION – NON-MANEUVER	(8045)	(3581)	(4464)
ORBITAL ACS	1325	292	1033
ENTRY ACS	2000	442	1658
COOLDOWN	60	40	20
ENGINE PURGE	102	102	0
BOILOFF	1289	1289	0
VENT LOSS (50LB He NOT INCL)	38	32	6
TRAPPED (NOT INCL 86LB He)	1344	551	793
ECLS	294	234	60
APU	953	528	425
FUEL CELLS	640	71	569
ABORT MISSION – NON-MANEUVER	(5389)	(2214)	(3175)
ROLL CONTROL	320	71	249
ONE ORBIT ACS	100	22	78
ENTRY	2000	442	1558
APU	953	528	425
TRAPPED	1344	551	793
FUEL CELLS	46	5	41
ECLS	243	234	9
BOILOFF	208	208	0
VENT LOSS	13	11	2
ENGINE PURGE	102	102	0
COOLDOWN	60	40	20

28.5° EASTERLY MISSION	TOTAL	H_2	O_2
DESIGN INJECTED WT. = 334,117 RESERVE ASCENT PROP. = 6415 DUMPABLE ASCENT PROP. = 4,133			
2.5 MIN. REQ. TO DUMP 10,548 LB FOR NOM. MISSION			
PROP. USED DURING DUMP = $\frac{30000 LB_F * 150 SEC}{444 SEC} = 10135 LB$			
ASSUME; FOR ABORT = $\frac{30000 LB_F * 60 SEC}{444 SEC} = 4054 LB$			
ABORT MISSION: 1005 FPS REQ. $I_{SP} = 444 * 4054/(4054+4133) = 219.86$ $W_O = 334,117 - 6415 = 327,702.$ $\Delta V_{\text{DURING DUMP}} = 219.86 g (L_N (327,702/319515)) = 179 FPS$ $1005 - 179 = 826 FPS$ $W_O = 319515$ $W_{PROP} = W_O (1 - e^{\frac{-826}{g 444}}) = 17952$ 4059 22006	22006	3668	18338
ABORT MISSION – NON MANEUVER	5389	2214	3175
TOTAL LOADED TO PROVIDE FOR ABORT	27395	5882	(21513)
NOMINAL MISSION: 800 FPS + 100 FPS $I_{SP} = 444 * 10135/(10548+10135) = 217.57$ $W_O = 334,117$ $\Delta V_{\text{DURING DUMP}} = 217.57 g (L_N (334117/313434)) = 447.32 FPS$ $W_O = 334,117 - 10548 - 10135 = 313434.$ OAMS MANEUVER $= W_O (1 - e^{\frac{-100}{g 379}})$ MR = 3.52 $= 2560.$ $W_O = 313434 - 2560 = 310874$ $\Delta V = 800 - 447.32 = 352.68$ OMS MANEUVER $= W_O (1 - e^{\frac{352.68}{g 444}})$ MR = 5 10135 17716	17716	2953	14763
NOMINAL MISSION – NON MANEUVER	8045	3581	4464
TOTAL LOADED TO PROVIDE NOM. MISSION	28321	(7099)	21222
TOTAL LOADED EXCESS O_2 NOM. MISSION	28612	7099	21513 (291)

55° RESUPPLY MISSION	TOTAL	H_2	O_2
DESIGN INJECTED W_T = 318,079 RESERVE ASCENT PROP. = 6302 DUMPABLE ASCENT PROP. = 4133 } 10435 PROP. USED DURING DUMP = 10135 NOMINAL " " " " 4054 ABORT			
NOMINAL MISSION: 1315 FPS + 185 FPS			
~~I_{SP}~~ = ~~444~~ * 10135/(10435+10135) = 218.76			
W_o = 318,079			
$\Delta V_{\text{DURING DUMP}} = 218.76 g \left(\text{Ln}\left(318079/297509\right)\right) = 470.6$ FPS			
W_o = 318,079 − 10435 − 10135 = 297509 LB			
OAMS MANEUVER = $W_o\left(1-e^{\frac{-185}{g\,379}}\right)_{MR=3.53} = 4480$	4480	989	3491
W_o = 297509 − 4480 = 293029 ΔV = 1315 − 470.56 = 844.44			
OMS MANEUVER = $W_o\left(1-e^{\frac{-844.44}{g\,444}}\right)_{MR=5} = 16820$ + 10135 = 26955	26955	4492	22463
NOMINAL MISSION-NON-MANEUVER	8045	3581	4464
TOTAL LOADED TO PROVIDE NOM. MISSION	39480	9062	30418

90° POLAR MISSION	TOTAL	H_2	O_2
DESIGN INJECTED W_T = 292,614 RESERVE ASCENT PROP. = 6,184 DUMPABLE ASCENT PROP. = 4,133 } 10317			
PROP USED DURING DUMP = 10135 NOMINAL " " " " = 4054 ABORT			
ABORT MISSION: 1085 FPS REQ. ISP = 444 * 4054/(4054+4133) = 219.86 W_0 = 292,614 − 6184 = 286,430. $\Delta V_{\text{DURING DUMP}} = 219.86 g(L_N(286,430/278243)) = 205.13$ FPS $\Delta V = 1085 - 205.13 = 879.86$ $W_0 = 286,430 - 4133 - 4054 = 278243$ $W_{PROP} = W_0(1 - e^{\frac{-879.86}{g\,444}}) = 16621$ 4054 20675	20675	3446	17229
ABORT MISSION - NON MANEUVER	5389	2214	3175
TOTAL LOADED TO PROVIDE FOR ABORT	26064	5660	(20404)
NOMINAL MISSION: 615FPS + 100FPS ISP = 444 * 10135/(10317+10135) = 220.02 W_0 = 292614 $\Delta V = 220.02g(L_N(292614/272162)) = 512.9$ FPS W_0 = 292614 − 10317 − 10135 = 272162 OAMS MANEUVER = $W_0(1 - e^{\frac{-100}{g\,309}}) = 2223$ MR = 3.55 W_0 = 272162 − 2223 = 269939 ΔV = 615 − 512.9 = 102.1	2223	491	1732
OMS MANEUVER = $W_0(1 - e^{\frac{-102.1}{g\,444}}) = 1922$ MR = 5 10125 12057	12057	2010	10047
NOMINAL MANEUVER - NON MANEUVER	8045	3581	4464
TOTAL LOADED TO PROVIDE NOM. MISSION	22325	(6082)	16243
TOTAL LOADED	26486	6082	20404
EXCESS O_2 NOM. MISSION			(4161)

90° POLAR MISSION	TOTAL	H_2	O_2
PROPELLANT TANK VOLUME $\rho_O = 70.6$ $\rho_H = 4.37$			
TOTAL M VOL	3103	2514	589
LESS 2% FOR INTERNAL STRUCT	62	50	12
NET USABLE PLUS ULLAGE	3041	2464	577
LESS 3% ULLAGE	91	74	17
NET PROPELLANT VOLUME	2950	2390	560
TANK CAPACITY ~ LBS	49980	10444	39536
TOTAL LOADED OAMS & UTILITY	26486	6082	20404
GROSS AVAILABLE FOR ASCENT	23494	4362	19132
NET AVAILABLE FOR ASCENT @ MR = 5	22958	3826	19132

3.1 References - References have been made throughout this report to places where supporting data would be available, therefore, for specific references see the section where the weight data is derived. However, there are additional data which may be of interest to the reader in describing the system requirements, characteristics, and operation.

Title	MDAC Report No.
Executive Summary	E0308-I
Technical Summary	E0308-II
Shuttle Systems	E0308-II-1
Orbiter	E0308-II-2(A)
Booster	E0308-II-3(A)
Program Acquisition Plan	E0308-III
Program Management	E0308-III-1
Engineering & Development	E0308-III-2
Operations	E0308-III-3
Facilities Utilization & Manufacturing	E0308-III-4
Test	E0308-III-5
Logistics & Maintenance	E0308-III-6
Program Cost & Schedule Estimated	E0308-III-7
Design Data Book	E0189
Baseline	E0189-1
Trade Studies	E0189-2
Cost & Bogies	E0189-3
Methodology	E0189-4
Summary Mass Properties Report	E0403
Design Drawings	E0409

Additional data in the form of MDAC internal memos are available on limited basis for supplementary information.

Title	MDAC Memo No.
Airframe	SSPI-E450-576
Main Propulsion	SSPI-E450-577
Attitude Control & Orbit Maneuver Propulsion	SSPI-E450-578
Air Breathing Propulsion	SSPI-E450-579
Flight Systems	SSPI-E450-580
Product Assurance	SSPI-E450-581
Materials & Processes	SSPI-E450-582
Ground Support Equipment	SSPI-E450-583
Abort	SSPI-E450-584
Mechanical Systems	SSPI-E450-585
Electrical Power	SSPI-E450-586
Hydraulic Power	SSPI-E450-587
Environmental Control & Life Support	SSPI-E450-588

Crew Systems	SSPI-E450-589
Avionics	SSPI-E450-590
Thermal Environment- Gasdynamics Heating	SSPI-E450-591
Orbiter Aerodynamics Data Book	SSPI-E450-592
Auxiliary Power Unit	SSPI-E450-593
Operations Site Evaluation	SSPI-E450-595

3.2 Cross-Coding of Weight

This section is attempting to provide additional visibility to the reader by a recoding of the weights data into a more inclusive coding. It is then up to the reader to eliminate those weight items which he feels are inappropriate. For example, the Propulsion-Ascent Group (6.0) is expanded to include the integral tankage and fuel tank insulation from the Body Group (3.0) and all fluids from groups 23.0, 25.0, 26.0 and 27.0. This type of coding is attempting to show the person interested in Ascent Propulsion the total which might be related in some manner to his system. This type of cross-coding is intended as an aid to the individual system specialist and cannot be used to arrive at a total vehicle weight since some items will appear several times in the coding. The main propulsion tank noted above as part of main propulsion is obviously a vital part of the body structure since it is an integral tank which carries primary loads and, therefore, must also appear in the Body Group. Page 3.2-2 shows a summary of the cross-coding results. Note that the only meaningful data is in a vertical column adding to the total inclusive system weight. Adding this table horizontally produces nothing! The remaining pages in the section show the individual weights which have been pulled from each code group.

The pages represent the detail items shown on the summary page. Each all-inclusive weight page begins with the basic code group and assumes all items in the group are applicable. Then the build-up of weight from the other code groups is shown.

The additional weights that have been transferred into a code group have carried no contingency from their own code group.

SUMMARY CROSS-CODING OF WEIGHT

CROSS	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	18.0	20.0	21.0	23.0	25.0	26.0	27.0	28.0	29.0
1.0 WING	31587			5272	518		1768									2872								
2.0 TAIL		5104		731												464								
3.0 BODY			55500	1996	330	21918										5046								
4.0 THD ENV. PROT.	8330		21181	32847		1886										2986								
5.0 LAND, DOCK, SEP.	6624		1603		10551											788								
6.0 PROP - ASCENT						26637					564					1010								
7.0 PROP - CRUISE							574									62								
8.0 PROP - ALT				1571				11877								1210								
9.0 PRIME PWR									2272							296								
10.0 ELECT C & D DIST										1303						170								
11.0 MEC CONT & DIST											2760					714								
12.0 GUID & CONT	2582	603								62	4901	4901				458								
13.0 AVIONICS										652			4588			599								
14.0 ENVIR CONT.	1097	63		3980	572	1103	415			855	272	236		7849		648								
15.0 RCS															430	20	430							
18.0 TOTAL INERT																25363								
20.0 PROPELLANT																	626							
21.0 CARGO																		65000						
23.0 VESTIBULAR FLUID					126	737		1430			1087	279		595					4001					
25.0 ESSENTIAL FLUIDS						6486		6382			148			102						13118				
26.0 INFLIGHT LOSSES						6467		1552	1445		805			324							9788			
27.0 PROPELLANT-ASC						526257																526257		
PROPELLANT-CRUISE																							0	
29.0 PROP - RCS/ACC								17510																17510
TOTAL	50240	5530	78284	46297	12097	591491	2757	38751	3717	2872	10537	5416	4588	8870	430	42706	1056	65000	4001	13118	9788	526257	0	17510

3.2-2

same as page 1-6 Figure 1-4

1.0 WING

1.0	WING		3158 -5
4.0	INDUCED ENVIR. PROT.		8330
	WING BTM.	5345.	
	ELEVON	2932.	
5.0	LANDING, DOCKING		6624.
	MAIN GEAR EXT.	6624.	
7.0	PROPULSION-CRUISE (REF. ONLY)(14244)		
	ENGINE & NACELLE	3337.5	
	ENGINE & NACELLE	3337.5	
	ENGINE & NACELLE	3337.5	
	ENGINE & NACELLE	3337.5	
	DEPLOY MECH	894.	
12.0	SURFACE CONTROLS		2582.
	ELEVON ACTUATOR	2066.	
	ELEV. SEC. ACT.	52.	
	ELEV SUPTS.	228.	
	ELEV. PWR. TRN	98.	
	ELEV. CNTLS.	138.	
14.0	ENVIRONMENTAL CONT.		1097
	INSULATION - MLG BAY	519.	
	INSULATION - ACTUATOR-ELEV.	163.	
	INSULATION - CRUISE ENG.	415.	

TOTAL 50220

2.0 TAIL

2.0 TAIL		5104. LB
12.0 SURFACE CONTROLS		663.
RUDDER ACT.	465.	
RUDDER SEC. ACT.	26.	
RUDDER SUPTS	67.	
RUDDER PWR TRN.	48.	
RUDDER CONTROLS	57.	
14.0 ENVIRONMENTAL CONT.		63.
INSULATION – ACTUATOR – RUDDER	63.	

TOTAL 5830

3.0 BODY

3.0 BODY		55500.LB.
4.0 INDUCED ENVIRONMENT PROT.		21181
BODY BTM.	13174.	
BODY SIDE & TOP	5369.	
BODY FLAP	752.	
BASE	1886.	
5.0 LANDING, DOCKING		1603
NOSE GEAR EX.	976.	
FWD. SEP. SYSTEM	244.	
AFT. OUTB'D SEP	192.	
AFT CENTER SEP	191.	

TOTAL 78284

4.0 INDUCED ENVIRONMENT PROTECTION

4.0 INDUCED ENV. PROT.		32847. LB.
1.0 WING		5272.
LEADING EDGE	5272.	
2.0 TAIL		731.
LEADING EDGE	731.	
3.0 BODY		1996.
LH2 INSULATION	1996.	
8.0 PROPULSION - AUX.		1571.
TANGAGE – HZ - INSULATION	1571.	
14.0 ENVIRONMENTAL CONT.		3980
PURGE LINER	677.	
SUPPLY & DISC. HEADER	426.	
INSULATION	2877.	

TOTAL 46397

5.0 LANDING, DOCKING SEPARATION

5.0 LANDING, DOCKING, SEPARATION		10551 LB.
1.0 WING		518.
MLG DOOR	518.	
3.0 BODY		330.
N.G. ATTACH & DOOR	330.	
14.0 ENVIRONMENTAL CONT.		572.
INSULATION – N.L.G. BAY	53.	
INSULATION - M.L.G BAY	519.	
23.0 RESIDUAL FLUIDS		126
MAIN GEAR STRUT OIL	84.	
NOSE GEAR STRUT OIL	42.	
TOTAL		12097

6.0 PROPULSION - ASCENT

6.0 PROPULSION - ASCENT		26637 LB.
3.0 BODY		21918.
LOX TANK	6042.	
LH2 TANK	9734.	
COMMON BLKHD	2876.	
LH2 INSULATION	1996.	
THRUST POSTS (ONLY)	1270.	
4.0 INDUCED ENVIR. CONT.		1886.
BASE	1100.	
BASE-ENG	526.	
BASE-ENG. IMP.	260.	
14.0 ENVIR. CONT.		1103.
PURGE LINER	677.	
SUPPLY & DISCHARGE HEADERS	426.	
23.0 RESIDUAL FLUIDS		737
ASCENT	737.	
25.0 RESERVE FLUIDS		6486
ASCENT	6486.	
26.0 INFLIGHT LOSSES		6467
ASCENT	6467.	
27.0 PROPELLANT - ASCENT		526257.
TOTAL		591491

7.0 PROPULSION-CRUISE

7.0 PROPULSION-CRUISE (15273. REF.)		574. LB
1.0 WING		1768.
ABES DOORS	1768.	
14.0 ENVIRONMENTAL CONT.		415.
CRUISE ENGINE	415.	
23.0 RESIDUAL FLUIDS		
TRAPPED JP	(180. REF)	
ENGINE LUB. OIL	(24. REF)	
24.0 RESERVE FLUIDS		
JP-4 GO-AROUND FUEL	(2280. REF.)	
28.0 PROPELLANT-CRUISE (1140. REF.)		
TOTAL	(21080. REF)	2757.

8.0 PROPULSION-AUXILIARY

8.0 PROPULSION-AUXILIARY		11877 LB
23.0 RESIDUAL FLUIDS		1430
MANEUVER & ATTITUDE	1430.	
25.0 RESERVE FLUIDS		6382
MANEUVER	4720.	
ATTITUDE	1662.	
26.0 INFLIGHT LOSSES		1552
AUXILIARY PROPULSION	1552.	
29.0 PROPELLANT-MAN/ACS		17510.

TOTAL	38751.

9.0 PRIME POWER

9.0 PRIME POWER		2272. LB
26.0 INFLIGHT LOSSES		1445.
EPS	640.	
HYDRAULIC (APU PROP.)	805.	

TOTAL 3717

10.0 ELECTRICAL CONVERSION & DISTRIBUTION

10.0 ELECTRICAL CONV. & DIST.		1303. LB.
6.0 PROPULSION ~ ASCENT		96.
GIMBAL SYS. CIRCUITRY	23.	
IGNITION & CONTROL ~ WIRING & MISC.	30.	
PROPELLANT UTILIZATION ~ WIRING & MISC.	43.	
7.0 PROPULSION ~ CRUISE		110.
IGNITION & CONTROL ~ WIRING & MISC.	30.	
ENGINE ACCESSORIES ~ INSTRUMENTATION	70.	
FIRE DETECTION ~ WIRING & MISC.	10.	
8.0 PROPULSION ~ AUXILIARY		56.
ATTITUDE CONTROL ~ WIRING, CONNECTORS & INSTL.	53.	
MANUEVER ~ " " "	3.	
11.0 HYDRAULIC		104.
POWER SUPPLY ~ CIRCUITRY	25.	
VALVES ~ CIRCUITRY	71.	
ELEC. PUMP ~ CIRCUITRY	8.	
12.0 SURFACE CONT		62.
ELEVON ~ CIRCUITRY	36.	
RUDDER ~ CIRCUITRY	18.	
SPEED BRAKE ~ CIRCUITRY	8.	
13.0 AVIONICS		652.
G & N CIRCUITRY	62.	
FLIGHT CONT. SYS. CIRCUITRY	44.	
DATA MANAGEMENT CIRCUITRY	238.	
COM. & NAVAIDS CIRCUITRY	117.	
DISPLAYS AND CONT. CIRCUITRY	191.	
14.0 ENVIRONMENTAL CONT.		914.
INSULATION ~ PWR. TRANS. TUNNEL	855.	
GAS SUPPLY ~ N_2 CIRCUITRY	2.	
" " ~ O_2 "	1.	
GAS MANAGEMENT "	6.	
CABIN AIRLOOP "	3.	
CABIN COOLANT LOOP CIRCUITRY	10.	
EQUIP. " " "	22.	
PRODUCT WATER SYSTEM "	10.	
WASTE MANAGEMENT "	5.	
TOTAL		3297

11.0 HYDRAULIC CONVERSION & DISTRIBUTION

11.0 HYDRAULIC CONV. & DIST.		2760 LB.
3.0 BODY GROUP ~ CARGO DOOR HYD. MOTORS		20.
6.0 PROPULSION – ASCENT		564.
GIMBAL ACTUATORS	564.	
7.0 PROPULSION – CRUISE (REF. ONLY)	(614.)	
ENGINE ACTUATORS	180.	
DOOR ACTUATORS	368.	
FLIPPER DOOR ACTUATOR	66.	
8.0 AUXILIARY PROP ~ DOOR ACTUATORS		22.
12.0 SURFACE CONT.		4901.
14.0 ENVIRONMENTAL CONT.		272.
INSULATION – ELEVON – ACT.	163.	
INSULATION – RUDDER – ACT.	63.	
INSULATION – SPEED BRAKE – ACT.	10.	
INSULATION – HYDRAULIC BAY	36.	
23.0 RESIDUAL FLUIDS		1087.
HYDRAULIC FLUID	1087.	
25.0 RESERVE FLUIDS		148.
HYDRAULIC (APU PROP.)	148.	
26.0 INFLIGHT LOSSES		805.
HYDRAULIC (APU PROP)	805.	
TOTAL		10579

12.0 SURFACE CONTROLS

12.0 SURFACE CONTROLS			4901 LB.
13.0 AVIONICS			217.
ACTUATOR ELECTRONICS		114.	
DISPLAYS & CONTROLS		103.	
SURF POSITION IND.	5.		
AERO AUTO PILOT PANELS	8.		
STICK & RUDDER PEDALS	90.		
14.0 ENVIRONMENTAL CONT.			236
INSULATION - ELEVON ACT.		163.	
INSULATION - RUDDER ACT.		63.	
INSULATION - SPEED BRAKE		10.	
23.0 RESIDUAL FLUIDS			279.
ACTUATOR FLUID - ELEVON		197.	
ACTUATOR FLUID - RUDDER		26.	
ACTUATOR FLUID - SPEED BRAKE		56.	
TOTAL			5633

13.0 AVIONICS

13.0 AVIONICS	4588 LB.

TOTAL	4588

14.0 ENVIRONMENTAL CONTROL

14.0 ENVIRONMENTAL CONTROL		7849 LB.
23.0 RESIDUAL FLUIDS		595.
ECS - FREON	435.	
ECS - WATER	96.	
ECS - OXYGEN	16.	
ECS - N2	48.	
25.0 RESERVE FLUIDS		102.
ECS - WATER	65.	
ECS - O_2 -EMER.	16.	
ECS - N_2	10.	
ECS - O_2 - MAIN SUPPLY	11.	
26.0 INFLIGHT LOSSES		324.
ECS - O_2	23.	
ECS - N_2	67.	
ECS - CRYO. COOLING	234.	

TOTAL 8870

15.0 PERSONNEL PROVISIONS

15.0 PERSONNEL PROV.	430 LB.

TOTAL	430

16.0 RANGE SAFETY

16.0 RANGE SAFETY	0 LB.

17.0 BALLAST

17.0 BALLAST	0 LB.

18.0 GROWTH/UNCERTAINTY

18.0 GROWTH/UNCERTAINTY		25363.
1.0 WING		2872.
CONTINGENCY	2872.	
2.0 TAIL		464.
CONTINGENCY	464.	
3.0 BODY		5046.
CONTINGENCY	5046.	
4.0 INDUCED ENV. PROT.		2986.
CONTINGENCY	2986.	
5.0 LANDING, DOCKING, SEP		788.
CONTINGENCY	788.	
6.0 PROPULSION-ASCENT		1010.
CONTINGENCY	1010.	
7.0 PROPULSION-CRUISE		62.
CONTINGENCY	62.	
8.0 PROPULSION-AUX.		1210.
CONTINGENCY	1210.	
9.0 PRIME POWER		296.
CONTINGENCY	296.	
10. ELECT. CONV & DIST.		170.
CONTINGENCY	170.	
11.0 HYDRAULIC CONV. & DIST		714.
CONTINGENCY	714.	

18.0 GROWTH/UNCERTAINTY (CONT.)

12.0 SURFACE CONTROLS		458.
CONTINGENCY	458.	
13.0 AVIONICS		599.
CONTINGENCY	599.	
14.0 ENVIRONMENTAL CONT.		648.
CONTINGENCY	648.	
15.0 PERSONNEL PROV.		20.
CONTINGENCY	20.	

TOTAL 42706.

20.0 PERSONNEL

20.0 PERSONNEL	626. LB
15.0 PERSONNEL PROV.	430.

TOTAL 1056

21.0 CARGO

21.0 CARGO 65000LB

23.0 RESIDUAL FLUIDS

23.0 RESIDUAL FLUIDS	4001 LB.

25.0 RESERVE FLUIDS

25.0 RESERVE FLUIDS	13118 LB.

26.0 INFLIGHT LOSSES

26.0 INFLIGHT LOSSES 9788 LB.

27.0 PROPELLANT - ASCENT

27.0 PROPELLANT - ASCENT 526257.LB

28.0 PROPELLANT-CRUISE

28.0 PROPELLANT-CRUISE 0 LB.

(REF. ONLY 1140.)

29.0 PROPELLANT - MANEUV/ACS

17.0 PROPELLANT - MAN./ACS 17510 LB.

3.3 Fluids Summary

The current inventory of fluids provides a complete summation of all fluids in a compact tabular form. This section includes a current fluids inventory and a propellant design data page for each mission.

65K Easterly Mission

CURRENT INVENTORY OF FLUIDS AND PROPELLANTS

PAGE 1 OF 2

CONFIGURATION: Delta Wing Orbiter | BY: | DATE:

SYSTEM	MAX. DENSITY (LB/ FT^3)	0% Ullage CAPACITY (LB)	TOTAL (LB)	EXPENDABLES (NOMINAL (LB)	INFLIGHT LOSSES (LB)	RESERVES (LB)	RESIDUALS (LB)
PROPULSION – ASCENT		(571831)	(539947)	(526257)	(6467)	(6486)	(737)
OXIDIZER (LOX)	71.2	490272	462823	451077	5589	5543	614
FUEL (LH_2)	4.4	81512	77077	75180	858	924	115
PRESSURANT (He)Stage Pneu	2.62	47	47		20	19	8
PROPULSION – CRUISE							
FUEL ( )							
PRESSURANT ( )							
PROPULSION – AUXILIARY		(51924)	(26874)	(17510)	(1552)	(6382)	(1430)
OXIDIZER ( )	71.2	41082	819		26		793
MANEUVER			17049	13067		3982	
ATTITUDE CONTROL			2591	1296		1295	
FUEL ( )	4.4	10842	2014		1463		551
MANEUVER			3518	2780		738	
ATTITUDE CONTROL			734	367		367	
PRESSURANT ( )			149		63		86
MANEUVER							
ATTITUDE CONTROL							
ENVIRONMENTAL CONTROL		[753]	[1047]	[0]	[324]	[102]	[621]
COOLING FLUID (FREON)	85	(435)	(435)	(0)	(0)	(0)	(435)
ATMOSPHERE (TOTAL)		(157)	(217)	(0)	(90)	(37)	(90)
OXYGEN		See Page 2					
DILUENT (H_2)		See Page 2					
WATER	62.4	(161)	(161)	(0)	(0)	(65)	(96)
COOLING		136	136	0	0	40	96
** DRINKING		25	25	0	0	25	0
** WASH + PURIFICATION		N/A	N/A	N/A	N/A	N/A	N/A
COOLING CRYOGEN (H_2)		***	(234)	(0)	(234)	(0)	(0)
PRIME POWER		(0)	(640)	(0)	(640)	(0)	(0)
*RADIATOR FLUID ( )	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FUEL CELL REACTANTS (OAMS TK)		***	(640)	(0)	(640)	(0)	(0)
OXIDIZER (O_2) OAMS TK		***	569	0	569	0	0
FUEL (H_2) OAMS TK		***	71	0	71	0	0

*** TANKED IN AUXILIARY PROPULSION TANKS.

** PROVIDED BY FUEL CELLS. DRY WEIGHT INCLUDES WATER STORAGE AND COLLECTION PROVISIONS.

* ONE RADIATOR CONTAINING TWO LOOPS PLUS TWO SEPARATE COOLING LOOPS ARE INTEGRATED AS A UNIFIED SYSTEM FOR PRIME POWER COOLING, AS WELL AS, LIFE SUPPORT AND AVIONICS EQUIPMENT MAINTENANCE.

65K Easterly Mission

CURRENT INVENTORY OF FLUIDS AND PROPELLANTS (Continued)

PAGE 2 OF 2

CONFIGURATION: Delta Wing Orbiter | BY: | DATE:

SYSTEM	DENSITY (LB/FT^3)	CAPACITY (LB)	TOTAL (LB)	EXPENDABLES (NOMINAL (LB)	INFLIGHT LOSSES (LB)	RESERVES (LB)	RESIDUALS (LB)
HYDRAULIC SYSTEM		(1087)	(2040)	0	(805)	(148)	(1087)
FLUID	51.8	1087	1087	0	0	0	1087
OXIDIZER (O_2)		***	425	0	359	66	0
FUEL (H_2)		***	528	0	446	82	0
ATMOSPHERE (TOTAL)		(157)	(217)	(0)	(90)	(37)	(90)
OXYGEN (REPRESS & LEAK-OAMS TK)		***	28	0	23	5	0
OXYGEN (METABOLIC - OAMS TK)		***	32	0	0	6	26
OXYGEN (EMERGENCY TANK)		17	17	0	0	16	1
DILUENT (N_2 TANK (REPRESS & LEAK)		81	81	0	67	10	4
ATMOSPHERE (INITIAL CABIN)		(59)	(59)	(0)	(0)	(0)	(59)
OXYGEN		15	15	0	0	0	15
DILUENT (N_2)		44	44	0	0	0	44
MISCELLANEOUS		(126)	(126)				(126)
TOTALS 65K EASTERLY			570674	543767	9788	13118	4001

65K EASTERLY

DESIGN DATA SUMMARY				PAGE 8 OF 8	
CONFIGURATION	DELTA WING ORBITER	BY		DATE	

27 – 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER/FUEL RATIO (BY WEIGHT)	6	N/A	5 ∈ 3,53	5 ∈ 3,53
OXIDIZER ULLAGE VOLUME – PERCENT*	5,5**		47,2	47,2
FUEL ULLAGE VOLUME – PERCENT*	5,5**		34,0	34,0
FUEL DENSITY – PCF	4,395		4,37	4,37
OXIDIZER DENSITY – PCF	71,0		70,6	70,6
FUEL BIAS – PERCENT	,25			
INCREMENTAL VELOCITY – FPS	(14032)		900	N/A
INERTIAL	13736			
MANEUVER LOSSES				
GRAVITY LOSSES	212			
DRAG LOSSES	2			
BACK PRESSURE LOSSES	29			
ANGLE OF ATTACK	53			
FLT PERFORMANCE RESERVE	290			
RANGE – NA MI		(_____)		
GROUND MILES		_____		
HEAD WIND ALLOW		_____		
CONTINGENCY		_____		
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING/GO-AROUND–MINUTES		_____		

* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES

** 3% PLUS 1% [illegible] MIN. ISP LOADING

25K 55° Mission W/ABES

CURRENT INVENTORY OF FLUIDS AND PROPELLANTS

PAGE 1 OF 2

CONFIGURATION: Delta Wing Orbiter | BY: | DATE:

SYSTEM	Max. DENSITY (LB/FT³)	0% Ullage CAPACITY (LB)	TOTAL (LB)	EXPENDABLES (NOMINAL (LB)	INFLIGHT LOSSES (LB)	RESERVES (LB)	RESIDUALS (LB)
PROPULSION – ASCENT		(571831)	(539947)	(526434)	(6467)	(6309)	(737)
OXIDIZER (LOX)	71.2	490272	462823	451229	5589	5391	614
FUEL (LH_2)	4.4	81512	77077	75205	858	899	115
PRESSURANT (He)Stg Pneu.	2.62	47	47		20	19	8
PROPULSION – CRUISE			(3624)	(1140)		(2280)	(204)
FUEL (JP)	48.67	3894	3600	1140		2280	180
PRESSURANT (MAIN ASCENT He RES.							
ENGINE OIL		24	24				24
PROPULSION – AUXILIARY		(51924)	(37742)	(28980)	(1552)	(5780)	(1430)
OXIDIZER ( )	71.2	41082	819		26		793
MANEUVER			25954	22529		3425	
ATTITUDE CONTROL			2591	1296		1295	
FUEL ( )	4.4	10842	2014		1463		551
MANEUVER			5481	4788		693	
ATTITUDE CONTROL			734	367		367	
PRESSURANT ( )			149		63		86
MANEUVER							
ATTITUDE CONTROL							
ENVIRONMENTAL CONTROL		[753]	[1047]	[0]	[324]	[102]	[621]
COOLING FLUID (FREON)	85	(435)	(435)	(0)	(0)	(0)	(435)
ATMOSPHERE (TOTAL)		(157)	(217)	(0)	(90)	(37)	(90)
OXYGEN		See Page 2					
DILUENT (H_2)		See Page 2					
WATER	62.4	(161)	(161)	(0)	(0)	(65)	(96)
COOLING		136	136	0	0	40	96
**DRINKING		25	25	0	0	25	0
**WASH + PURIFICATION		N/A	N/A	N/A	N/A	N/A	N/A
COOLING CRYOGEN (H_2)		***	(234)	(0)	(234)	(0)	(0)
PRIME POWER		(0)	(640)	(0)	(640)	(0)	(0)
*RADIATOR FLUID ( )	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FUEL CELL REACTANTS (OAMS TK)		***	(640)	(0)	(640)	(0)	(0)
OXIDIZER (O_2) OAMS TK		***	569	0	569	0	0
FUEL (H_2) OAMS TK		***	71	0	71	0	0
*** TANKED IN AUXILIARY PROPULSION TANKS							
** PROVIDED BY FUEL CELLS, DRY WEIGHT INCLUDES WATER STORAGE AND COLLECTION PROVISIONS.							

* ONE RADIATOR CONTAINING TWO LOOPS PLUS TWO SEPARATE COOLING LOOPS ARE INTEGRATED AS A UNIFIED SYSTEM FOR PRIME POWER COOLING, AS WELL AS, LIFE SUPPORT AND AVIONICS EQUIPMENT MAINTENANCE.

25K 55" MISSION W/ABES

CURRENT INVENTORY OF FLUIDS AND PROPELLANTS (Continued)

PAGE 2 OF 2

CONFIGURATION: Delta Wing Orbiter | BY: | DATE:

SYSTEM	DENSITY (LB/FT^3)	CAPACITY (LB)	TOTAL (LB)	EXPENDABLES (NOMINAL (LB)	INFLIGHT LOSSES (LB)	RESERVES (LB)	RESIDUALS (LB)
HYDRAULIC SYSTEM		(1087)	(2040)	0	(805)	(148)	(1087)
FLUID	51.8	1087	1087	0	0	0	1087
OXIDIZER (O_2)		***	425	0	359	66	0
FUEL (H_2)		***	528	0	446	82	0
ATMOSPHERE (TOTAL)		(157)	(217)	(0)	(90)	(37)	(90)
OXYGEN (REPRESS & LEAK.-OAMS TK)		***	28	0	23	5	0
OXYGEN (METABOLIC-OAMS TK)		***	32	0	0	6	26
OXYGEN (EMERGENCY TANK)		17	17	0	0	16	1
DILUENT (N_2 TANK)(REPRESS & LEAK)		81	81	0	67	10	4
ATMOSPHERE (INITIAL CABIN)		(59)	(59)	(0)	(0)	(0)	(59)
OXYGEN		15	15	0	0	0	15
DILUENT (N_2)		44	44	0	0	0	44
MISCELLANEOUS		(126)	(126)				(126)
TOTALS - RESUPPLY			585166	556554	9788	14619	4205

25K, 55° MISSION W/ABES

DESIGN DATA SUMMARY				PAGE 8 OF 8
CONFIGURATION	DELTA WING ORBITER	BY		DATE	

27 – 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER/FUEL RATIO (BY WEIGHT)	6	N/A	5 & 3.53	5 & 3.53
OXIDIZER ULLAGE VOLUME – PERCENT*	5.5**		25.3	25.3
FUEL ULLAGE VOLUME – PERCENT*	5.5**		15.8	15.8
FUEL DENSITY – PCF	4.395		4.37	4.37
OXIDIZER DENSITY – PCF	71.0		70.6	70.6
FUEL BIAS – PERCENT	.25			
INCREMENTAL VELOCITY – FPS	(14430)		1500	N/A
INERTIAL	14126			
MANEUVER LOSSES				
GRAVITY LOSSES	213			
DRAG LOSSES	2			
BACK PRESSURE LOSSES	29			
ANGLE OF ATTACK	60			
FLT PERFORMANCE RESERVE	295			
RANGE – NA MI		(_____)		
GROUND MILES		_____		
HEAD WIND ALLOW		_____		
CONTINGENCY		_____		
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING/GO-AROUND–MINUTES		_____		

* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES

** 3% PLUS 1% LOAD ALLOWANCE FOR ASYM. ISP LOADING

40K POLAR MISSION

CURRENT INVENTORY OF FLUIDS AND PROPELLANTS

PAGE 1 OF 2

CONFIGURATION: DELTA WING ORBITER | BY: | DATE:

SYSTEM	MAX. DENSITY (LB/FT^3)	0% ULLAGE CAPACITY (LB)	TOTAL (LB)	EXPENDABLES (NOMINAL (LB)	INFLIGHT LOSSES (LB)	RESERVES (LB)	RESIDUALS (LB)
PROPULSION – ASCENT		(571831)	(562315)	(548927)	(6467)	(6184)	(737)
OXIDIZER (LOX)	71.2	490272	462823	451336	5589	5284	614
FUEL (LH_2)	4.4	81512	77077	75223	858	881	115
PRESSURANT (He)	2.62	47	47		20	19	8
OXIDIZER (LOX)		***	17894	17894			
FUEL (LH_2)		***	4474	4474			
PROPULSION – AUXILIARY		(51924)	(24748)	(12022)	(1552)	(9744)	(1430)
OXIDIZER ( )	71.2	41082	819		26		793
MANEUVER			15940	8512		7428	
ATTITUDE CONTROL			2591	1296		1295	
FUEL ( )	4.4	10842	2014		1463		551
MANEUVER			2501	1847		654	
ATTITUDE CONTROL			734	367		367	
PRESSURANT ( )			149		63		86
MANEUVER							
ATTITUDE CONTROL							
ENVIRONMENTAL CONTROL		[753]	[1047]	[0]	[324]	[102]	[621]
COOLING FLUID (FREON)	85	(435)	(435)	(0)	(0)	(0)	(435)
ATMOSPHERE (TOTAL)		(157)	(217)	(0)	(90)	(37)	(90)
OXYGEN		See Page 2					
DILUENT (N_2)		See Page 2					
WATER	62.4	(161)	(161)	(0)	(0)	(65)	(96)
COOLING		136	136	0	0	40	96
*** DRINKING		25	25	0	0	25	0
** WASH + PURIFICATION		N/A	N/A	N/A	N/A	N/A	N/A
COOLING CRYOGEN (H_2)		***	(234)	(0)	(234)	(0)	(0)
PRIME POWER		(0)	(640)	(0)	(640)	(0)	(0)
*RADIATOR FLUID ( )	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FUEL CELL REACTANTS		***	(640)	(0)	(640)	(0)	(0)
OXIDIZER (O_2)		***	569	0	569	0	0
FUEL (H_2)		***	71	0	71	0	0
*** TANKED IN AUXILIARY PROPULSION TANKS.							
** PROVIDED BY FUEL CELLS, DRY WEIGHT INCLUDES WATER STORAGE AND COLLECTION PROVISIONS.							

* ONE RADIATOR CONTAINING TWO LOOPS PLUS TWO SEPARATE COOLING LOOPS ARE INTEGRATED AS A UNIFIED SYSTEM FOR PRIME POWER COOLING, AS WELL AS, LIFE SUPPORT AND AVIONICS EQUIPMENT MAINTENANCE.

40K POLAR MISSION

CURRENT INVENTORY OF FLUIDS AND PROPELLANTS (Continued)

PAGE 2 OF 2

CONFIGURATION: DELTA WING ORBITER | BY: | DATE:

SYSTEM	DENSITY (LB/FT^3)	CAPACITY (LB)	TOTAL (LB)	EXPENDABLES (NOMINAL (LB)	INFLIGHT LOSSES (LB)	RESERVES (LB)	RESIDUALS (LB)
HYDRAULIC SYSTEM		(1087)	(2040)	0	(805)	(148)	(1087)
FLUID	51.8	1087	1087	0	0	0	1087
OXIDIZER (O_2)		***	425	0	359	66	0
FUEL (H_2)		***	528	0	446	82	0
ATMOSPHERE (TOTAL)		(157)	(217)	(0)	(90)	(37)	(90)
OXYGEN (REPRESS & LEAK,-OAMS TK)		***	28	0	23	5	0
OXYGEN (METABOLIC - OAMS TK)		***	32	0	0	6	26
OXYGEN (EMERGENCY TANK)		17	17	0	0	16	1
DILUENT (N_2 TANK)(REPRESS & LEAK)		81	81	0	67	10	4
ATMOSPHERE (INITIAL CABIN)		(59)	(59)	(0)	(0)	(0)	(59)
OXYGEN		15	15	0	0	0	15
DILUENT (N_2)		44	44	0	0	0	44
MISCELLANEOUS		(126)	(126)				(126)
TOTALS POLAR			590916	560949	9788	16178	4001

40 K POLAR

DESIGN DATA SUMMARY				PAGE 8 OF 8	
CONFIGURATION	DELTA WING ORBITER	BY		DATE	

27 – 29 PROPELLANTS EXPENDED

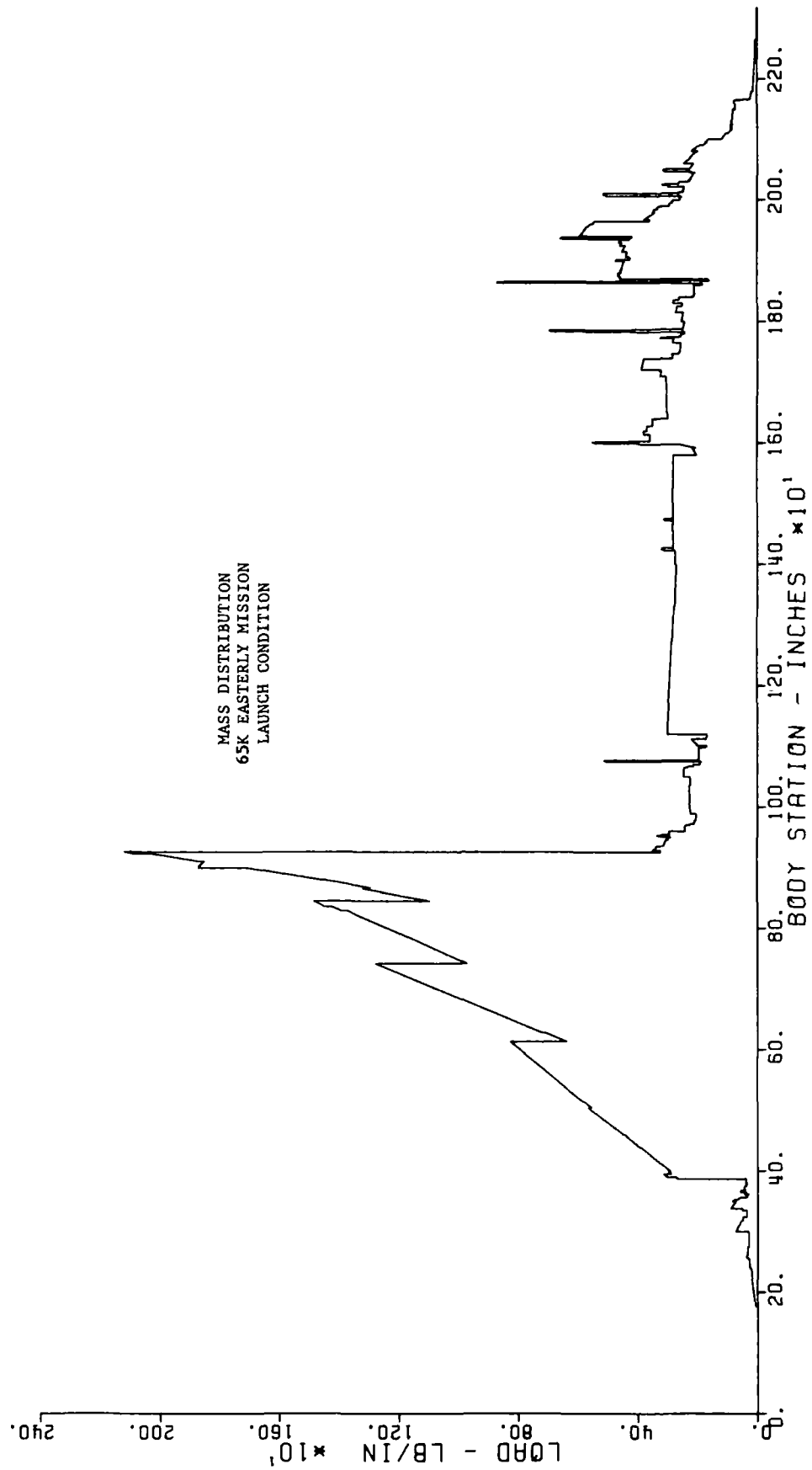
	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER/FUEL RATIO (BY WEIGHT)	6	N/A	5 @ 3.52	5 @ 3.53
OXIDIZER ULLAGE VOLUME – PERCENT*	5.5 **		49.9	49.9
FUEL ULLAGE VOLUME – PERCENT*	5.5 **		43.5	43.5
FUEL DENSITY – PCF	4.395		4.37	4.37
OXIDIZER DENSITY – PCF	71.0		70.6	70.6
FUEL BIAS – PERCENT	.25			
INCREMENTAL VELOCITY – FPS	(15238)		715	N/A
INERTIAL	14905			
MANEUVER LOSSES				
GRAVITY LOSSES	220			
DRAG LOSSES	2			
BACK PRESSURE LOSSES	29			
ANGLE OF ATTACK	82			
FLT PERFORMANCE RESERVE	204			
RANGE – NA MI		(_____)		
GROUND MILES		_____		
HEAD WIND ALLOW		_____		
CONTINGENCY		_____		
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING/GO-AROUND–MINUTES		_____		

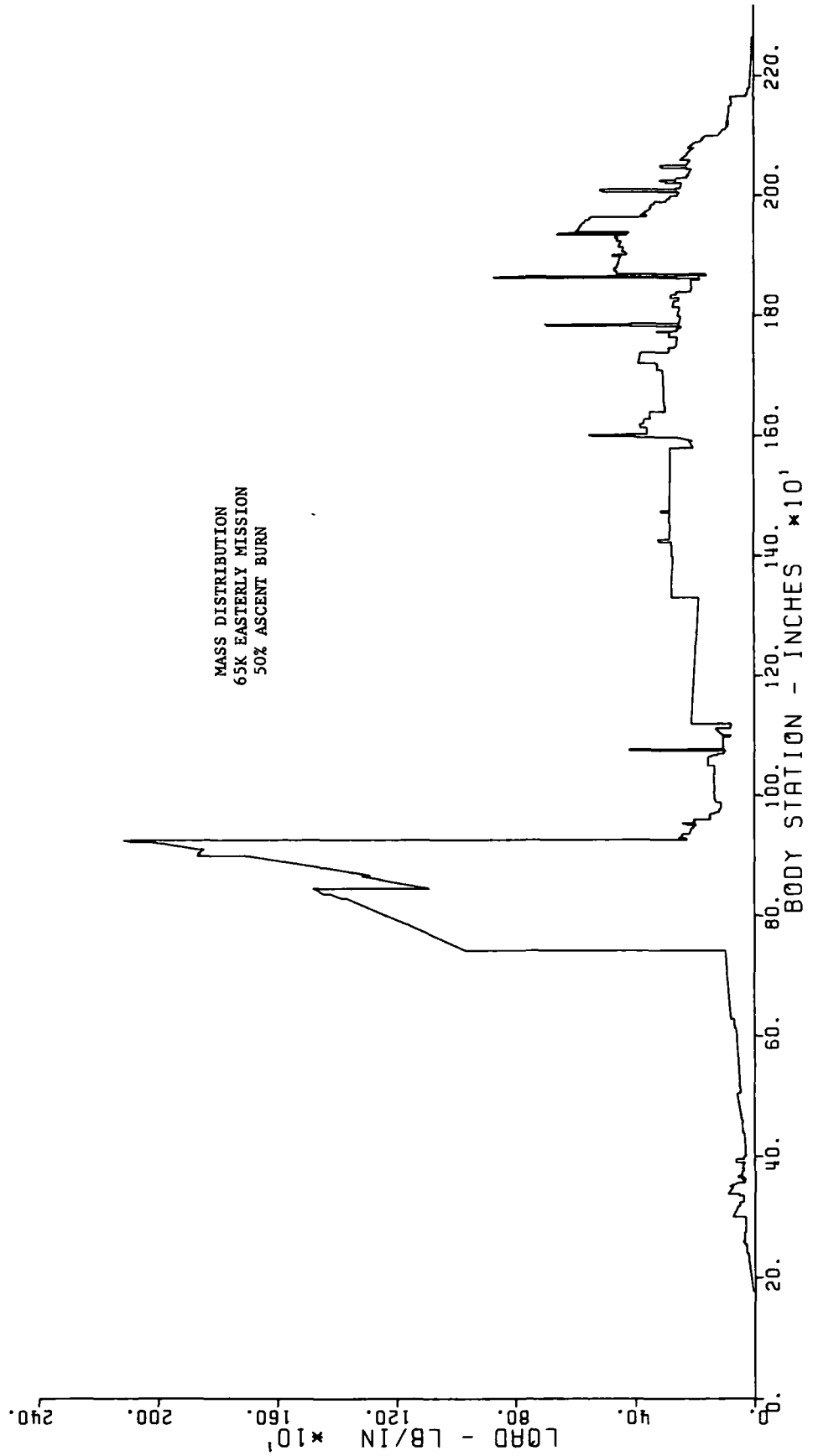
* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES

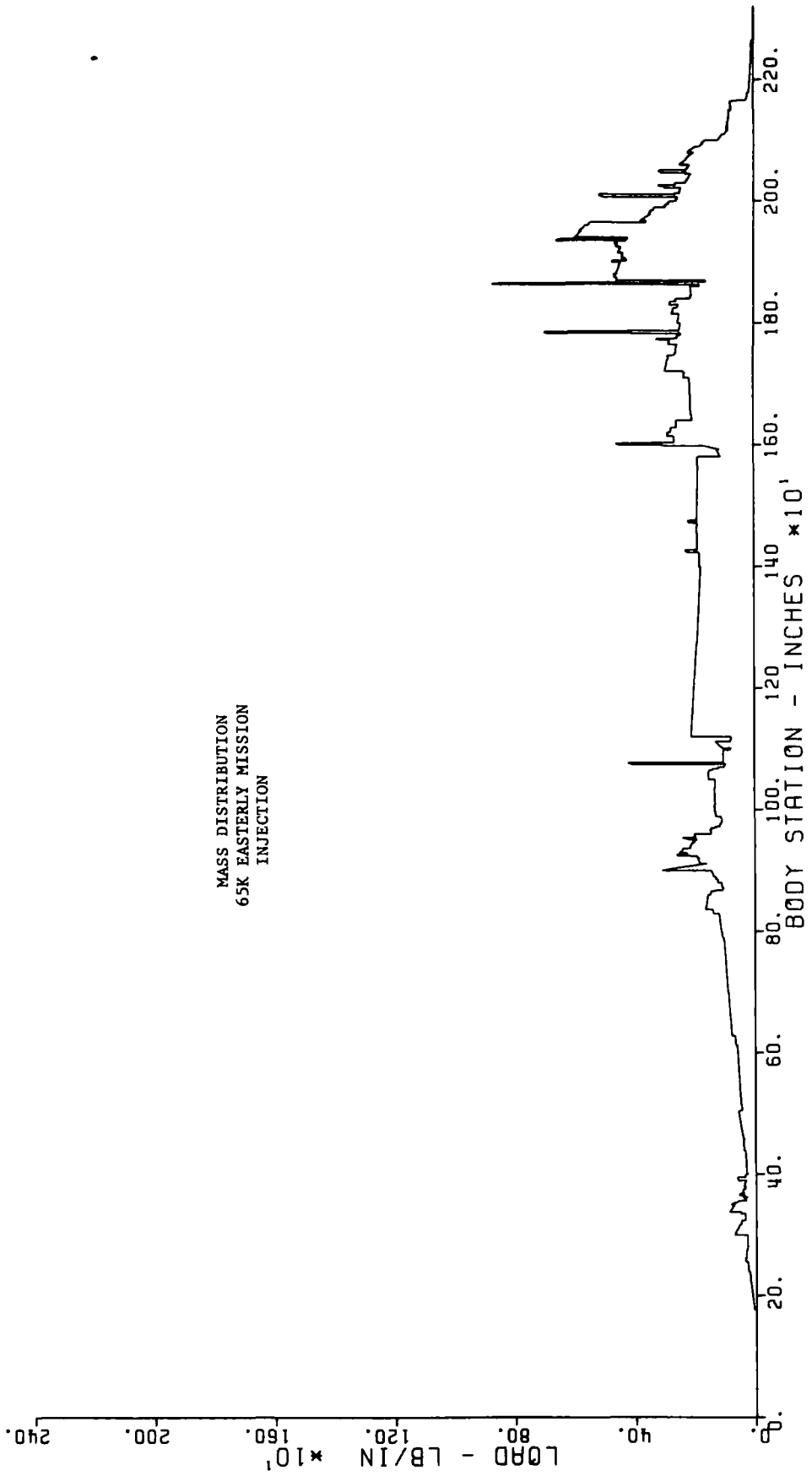
** 3% PLUS 1% LOAD ALLOWANCE FOR MIN. ISP LOADING

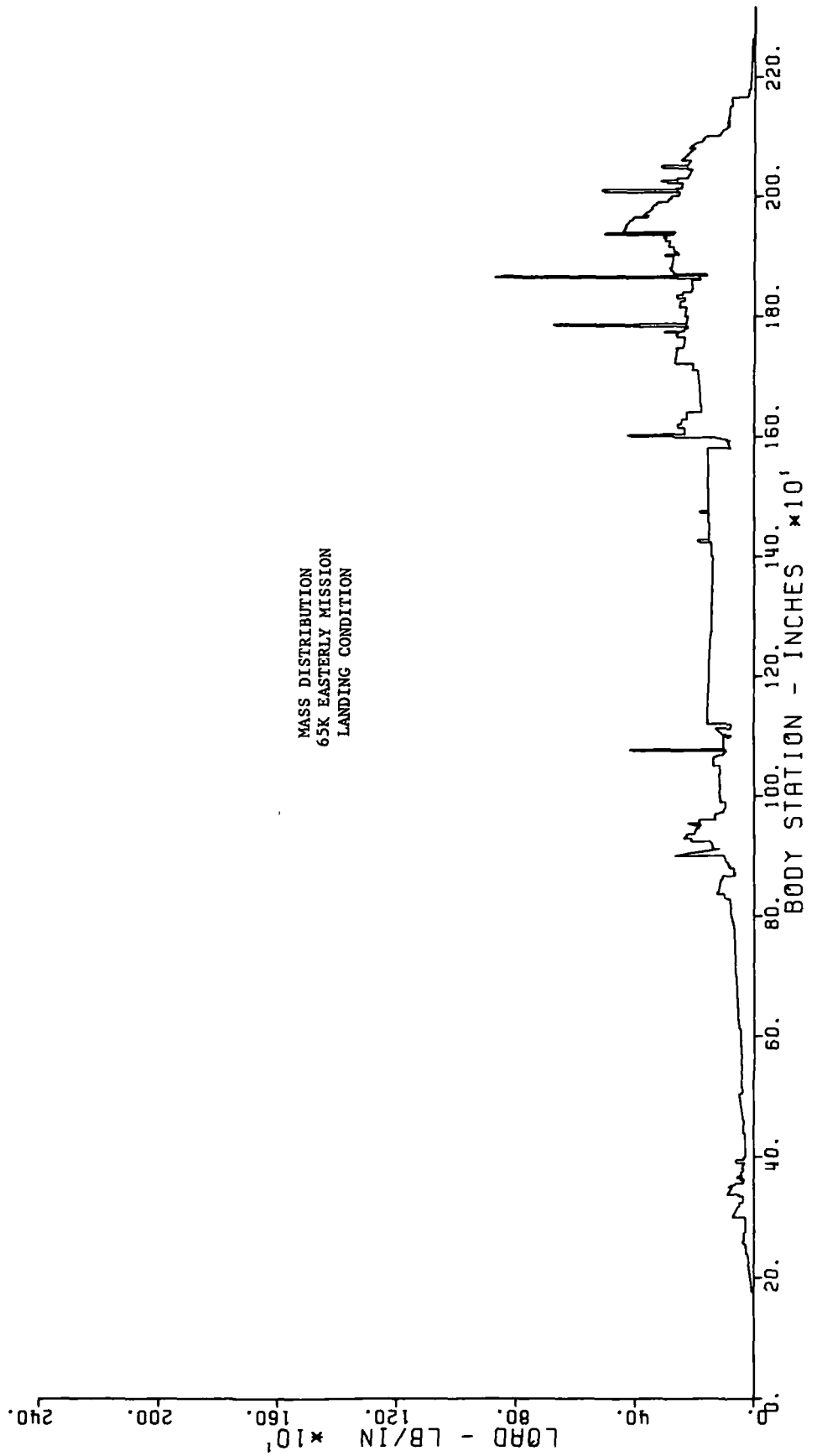
Appendix A

This appendix contains the mass distribution for launch, 50% burn, injection, and landing and the detail build-up of component weight, center-of-gravity, moment of inertia and product of inertia for the 65K easterly mission.

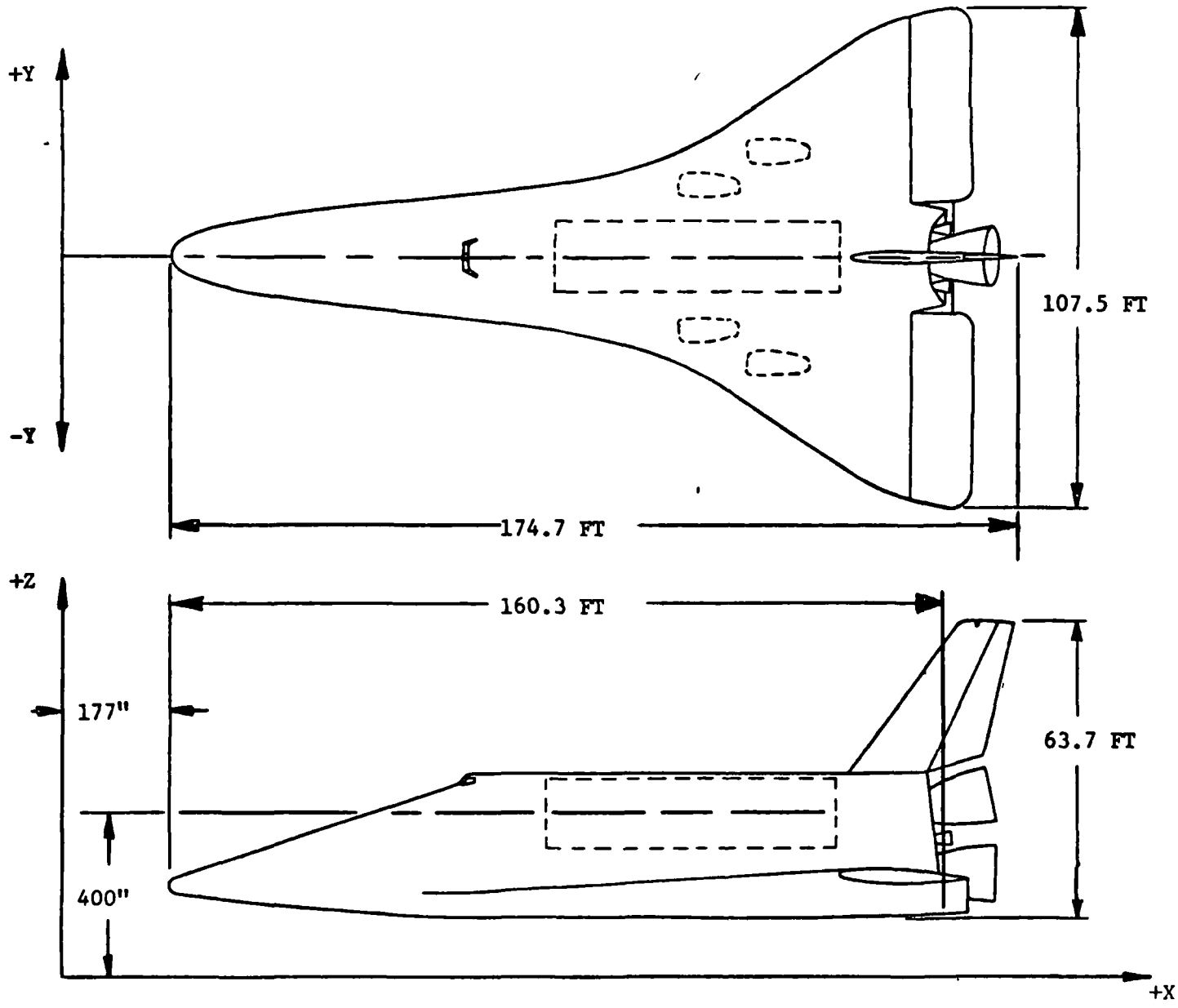

MASS DISTRIBUTION
65K EASTERLY MISSION
LAUNCH CONDITION
BODY STATION - INCHES *10¹
0.
20.
40.
60.
80.
100.
120.
140.
160.
180.
200.
220.
LOAD - LB/IN *10¹
0.
40.
80.
120.
160.
200.
240.


MASS DISTRIBUTION
65K EASTERLY MISSION
50% ASCENT BURN
LOAD - LB/IN *10¹
0.
40.
80.
120.
160.
200.
240.
BODY STATION - INCHES *10¹
0.
20.
40.
60.
80.
100.
120.
140.
160.
180.
200.
220.


MASS DISTRIBUTION
65K EASTERLY MISSION
INJECTION
LOAD - LB/IN ×10¹
0.
40.
80.
120.
160.
200.
240.
BODY STATION - INCHES ×10¹
0.
20.
40.
60.
80.
100.
120.
140.
160.
180.
200.
220.


MASS DISTRIBUTION
65K EASTERLY MISSION
LANDING CONDITION
LOAD - LB/IN *10'
0.
40.
80.
120.
160.
200.
240.
BODY STATION - INCHES *10'
0.
20.
40.
60.
80.
100.
120.
140.
160.
180.
200.
220.

CONFIGURATION/COORDINATE AXES					
CONFIGURATION	DELTA WING ORBITER	BY		DATE	



SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
65K EASTERLY MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	31587.	1738.	0.	194.	549.	423.	962.
					0.	0.	4.
TAILS	5104.	2054.	0.	632.	2.	11.	11.
					0.	0.	2.
BODY	55500.	1292.	0.	291.	191.	2605.	2551.
					0.	0.	82.
THERMAL PROT	32847.	1353.	-0.	191.	388.	2734.	3095.
					-0.	-0.	-6.
LANDING/DOCK	10551.	1438.	-0.	129.	102.	432.	452.
					-0.	-0.	-36.
PROP-ASCENT	26637.	1863.	4.	320.	42.	416.	395.
					-3.	-1.	3.
PROP-CRUISE	574.	1542.	25.	288.	3.	2.	4.
					0.	-0.	-0.
PROP-AUXIL	11877.	1291.	6.	320.	31.	677.	691.
					-0.	1.	-28.
PRIME POWER	2272.	1015.	-31.	258.	1.	264.	265.
					-12.	-0.	9.
ELEC DIST	1303.	832.	-16.	235.	0.	48.	48.
					-2.	-0.	2.
HYDRA DIST	2760.	1705.	-52.	262.	5.	42.	45.
					-2.	-0.	3.
SURF CONTROL	4901.	1944.	0.	308.	92.	33.	71.
					0.	0.	7.
AVIONICS	4588.	1030.	1.	384.	12.	101.	99.
					1.	-0.	-5.
ENVIR CONTRL	7849.	1124.	0.	363.	41.	250.	245.
					-0.	-0.	-11.
PERSNL PROV	430.	962.	7.	451.	0.	0.	0.
					-0.	-0.	-0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	25363.	1479.	0.	269.	0.	0.	0.
					0.	0.	0.
DRY WEIGHT	224142.	1479.	-0.	269.	1753.	11431.	11985.
					-11.	2.	167.
PERSONNEL	626.	951.	-1.	455.	0.	0.	0.
					-0.	-0.	-0.
LANDED CARGO	40000.	1420.	0.	400.	35.	410.	410.
					0.	0.	0.
RESID FLUIDS	4001.	1385.	0.	279.	20.	252.	238.
					0.	-0.	-20.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
65K EASTERLY MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
INERT WEIGHT	268769.	1468.	-0.	289.	1938.	12291.	12703.
					-11.	2.	79.
RESERVE FLDS	6651.	1712.	0.	287.	12.	248.	255.
					0.	-0.	-23.
LANDING WT	275420.	1474.	-0.	289.	1950.	12622.	13041.
					-11.	2.	55.
CRUISE PROP	37.	17869.	0.	23401.	-4332.	-6389.	-2056.
					0.	0.	-3039.
FLIGHT WT	275457.	1476.	-0.	292.	1883.	12645.	13132.
					-11.	2.	42.
ENTRY ACS	1834.	1477.	-0.	307.	3.	105.	106.
					-0.	0.	-9.
ENTRY WT	277291.	1476.	-0.	293.	1885.	12751.	13238.
					-11.	2.	33.
RETRO PROP	5536.	1741.	0.	283.	9.	183.	189.
					0.	-0.	-16.
PRE RETRO WT	282827.	1481.	-0.	292.	1895.	13016.	13509.
					-11.	2.	14.
ON ORB LOSS	11360.	1600.	0.	295.	18.	568.	577.
					0.	-0.	-49.
LANDED CARGO	-40000.	1420.	0.	400.	-35.	-410.	-410.
					0.	0.	0.
ASCENT CARGO	65000.	1420.	0.	400.	57.	667.	667.
					0.	0.	0.
ON ORBIT WT	319187.	1481.	-0.	301.	1993.	13953.	14398.
					-11.	2.	-69.
MANEUV PROP	1993.	1741.	-0.	283.	3.	66.	68.
					-0.	0.	-6.
DUMPED PROP	10600.	813.	0.	228.	5.	84.	88.
					0.	-0.	-0.
INJECTION WT	331780.	1461.	-0.	298.	2012.	15137.	15577.
					-11.	2.	31.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
65K EASTERLY MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ASCENT PROP	131860.	997.	0.	228.	103.	1946.	2048.
					0.	0.	-0.
75% BURN	463640.	1329.	-0.	278.	2216.	21574.	22015.
					-12.	2.	696.
ASCENT PROP	131701.	888.	0.	228.	89.	1421.	1509.
					0.	0.	1.
50% BURN	595341.	1231.	-0.	267.	2361.	27346.	27819.
					-13.	2.	1188.
ASCENT PROP	131569.	763.	0.	228.	64.	1034.	1098.
					0.	0.	0.
25% BURN	726910.	1147.	-0.	260.	2461.	33520.	34022.
					-14.	1.	1616.
ASCENT PROP	131570.	592.	-0.	228.	83.	892.	975.
					0.	0.	0.
IGNITION	858480.	1062.	-0.	255.	2568.	41824.	42383.
					-14.	1.	2045.
STARTUP	1962.	861.	0.	228.	1.	24.	25.
					0.	0.	0.
LAUNCH WT	860442.	1061.	-0.	255.	2570.	41865.	42425.
					-14.	1.	2047.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

UPR TB SKIN	633.	1880.	315.	221.	127.	47.	127.	0	1785.	2009.
UPR TB SKIN	633.	1880.	-315.	221.	127.	47.	127.	0	1785.	2009.
UPR FW SKIN	367.	1698.	249.	221.	83.	75.	83.	0	1425.	1785.
UPR FW SKIN	367.	1698.	-249.	221.	83.	75.	83.	0	1425.	1785.
LWR TB SKIN	579.	1880.	315.	185.	127.	47.	127.	0	1785.	2009.
LWR TB SKIN	579.	1880.	-315.	185.	127.	47.	127.	0	1785.	2009.
LWR FW SKIN	420.	1698.	249.	185.	83.	75.	83.	0	1425.	1785.
LWR FW SKIN	420.	1698.	-249.	185.	83.	75.	83.	0	1425.	1785.

SKIN

W= 3998.0	X=	1808.35	Y=	0.00	Z=		203.01
RAD OF GYRATION	KROLL=	312.07	KPIT=	108.54	KYAW=		323.98
MOM OF INERTIA	ROLL=	84036.	PITCH=	10167.	YAW=		90578.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		75.

UPR TB STRTG	344.	1880.	315.	221.	127.	47.	127.	0	1785.	2009.
UPR TB STRTG	344.	1880.	-315.	221.	127.	47.	127.	0	1785.	2009.
UPR FW STRG	487.	1698.	249.	221.	83.	75.	83.	0	1425.	1785.
UPR FW STGR	487.	1698.	-249.	221.	83.	75.	83.	0	1425.	1785.
LWR TB STGR	196.	1880.	315.	185.	127.	47.	127.	0	1785.	2009.
LWR TB STGR	196.	1880.	-315.	185.	127.	47.	127.	0	1785.	2009.
LWR FW STGR	143.	1698.	249.	185.	83.	75.	83.	0	1425.	1785.
LWR FW STGR	143.	1698.	-249.	185.	83.	75.	83.	0	1425.	1785.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

STGR

W= 2340.0	X=	1782.00	Y=	0.00	Z=	210.57				
RAD OF GYRATION	KROLL=	301.00	KPITCH=	111.99	KYAW=	313.95				
MOM OF INERTIA	ROLL=	45760.	PITCH=	6335.	YAW=	49780.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-112.				
FWD SPAR	146.	1600.	349.	221.	63.	75.	121.	0	1425.	1785.
FWD SPAR	146.	1600.	-349.	221.	63.	75.	121.	0	1425.	1785.
AFT SPAR	58.	1865.	512.	221.	35.	47.	75.	0	1785.	2009.
AFT SPAR	58.	1865.	-512.	221.	35.	47.	75.	0	1785.	2009.

L.E.SPAR

W= 408.0	X=	1675.34	Y=	0.00	Z=	221.00				
RAD OF GYRATION	KROLL=	406.07	KPITCH=	137.63	KYAW=	433.67				
MOM OF INERTIA	ROLL=	14521.	PITCH=	1668.	YAW=	16562.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
AUX FRONT	79.	1425.	192.	181.	28.	10.	28.	0	1423.	1427.
AUX FRONT	79.	1425.	-192.	181.	28.	10.	28.	0	1423.	1427.

AUX FRONT

W= 158.0	X=	1425.00	Y=	0.00	Z=	181.00				
RAD OF GYRATION	KROLL=	194.03	KPITCH=	10.00	KYAW=	194.03				
MOM OF INERTIA	ROLL=	1284.	PITCH=	3.	YAW=	1284.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.				

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

AUX REAR	256.	1600.	241.	191.	61.	10.	61.	0	1598.	1602.
AUX REAR	256.	1600.	-241.	191.	61.	10.	61.	0	1598.	1602.

AUX REAR

W= 512.0	X=	1600.00	Y=	0.00	Z=		191.00
RAD OF GYRATION	KROLL=	248.60	KPIT=	10.00	KYAW=		248.60
MOM OF INERTIA	ROLL=	6830.	PITCH=	11.	YAW=		6830.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=		0.

FRONT SPAR	336.	1785.	190.	196.	81.	20.	81.	0	1783.	1787.
FRONT SPAR	336.	1785.	-190.	196.	81.	20.	81.	0	1783.	1787.

FRONT SPAR

W= 672.0	X=	1785.00	Y=	0.00	Z=		196.00
RAD OF GYRATION	KROL=	206.55	KPIT=	20.00	KYAW=		206.55
MOM OF INERTIA	ROLL=	6188.	PITCH=	58.	YAW=		6188.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=		0.

MID SPAR	202.	1865.	200.	211.	101.	20.	101.	0	1863.	1867.
MID SPAR	202.	1865.	-200.	211.	101.	20.	101.	0	1863.	1867.

MID SPAR

W= 404.0	X=	1865.00	Y=	0.00	Z=		211.00
RAD OF GYRATION	KROL=	224.06	KPIT=	19.98	KYAW=		224.05
MOM OF INERTIA	ROLL=	4378.	PITCH=	35.	YAW=		4377.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=		-0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS = INCH

REAR SPAR	137.	2009.	220.	211.	127.	20.	127.	0	2007.	2011.
REAR	137.	2009.	-220.	211.	127.	20.	127.	0	2007.	2011.

REAR SPAR

W= 274.0	X=	2009.00	Y=	0.00	Z=	211.00
RAD OF GYRATION	KROL=	254.03	KPIT=	19.98	KYAW=	254.02
MOM OF INERTIA	ROLL=	3816.	PITCH=	24.	YAW=	3816.
PROD OF INERTIA	ROL*PIT=	0.	PIT*YAW=	0.	YAW*ROL=	0.

FWD	568.	1600.	140.	181.	10.	75.	75.	0	1425.	1785.
FWD	568.	1600.	-140.	181.	10.	75.	75.	0	1425.	1785.
AFT	408.	1865.	155.	181.	10.	64.	64.	0	1785.	2009.
AFT	408.	1865.	-155.	181.	10.	64.	64.	0	1785.	2009.

ROOT RIB

W= 1952.0	X=	1710.78	Y=	0.00	Z=	181.00
RAD OF GYRATION	KROL=	146.80	KPIT=	148.55	KYAW=	208.61
MOM OF INERTIA	ROLL=	9079.	PITCH=	9298.	YAW=	18335.
PROD OF INERTIA	ROL*PIT=	0.	PIT*YAW=	0.	YAW*ROL=	0.

RIB 2	297.	1600.	170.	185.	10.	75.	75.	0	1425.	1785.
RIB 2	297.	1600.	-170.	185.	10.	75.	75.	0	1425.	1785.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS = INCH

RIB 2

W= 594.0	X= 1600.00	Y= 0.00	Z= 185.00
RAD OF GYRATION	KROLL= 170.29	KPIT= 75.00	KYAW= 185.81
MOM OF INERTIA	ROLL= 3718.	PITCH= 721.	YAW= 4426.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

RIB 2A	50.	1895.	183.	182.	10.	64.	64.	0	1785.	2009.
RIB 2A	50.	1895.	-183.	182.	10.	64.	64.	0	1785.	2009.

RIB 2A

W= 100.0	X= 1895.00	Y= 0.00	Z= 182.00
RAD OF GYRATION	KROL= 183.27	KPIT= 64.00	KYAW= 193.87
MOM OF INERTIA	ROLL= 725.	PITCH= 88.	YAW= 811.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

RIB 2B	75.	1900.	202.	183.	10.	64.	64.	0	1785.	2009.
RIB 2B	75.	1900.	-202.	183.	10.	64.	64.	0	1785.	2009.

RIB 2B

W= 150.0	X= 1900.00	Y= 0.00	Z= 183.00
RAD OF GYRATION	KROL= 202.25	KPIT= 64.00	KYAW= 211.90
MOM OF INERTIA	ROLL= 1324.	PITCH= 133.	YAW= 1454.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

FWD	654.	1650.	240.	183.	10.	75.	75.	0	1425.	1785.
FWD	654.	1650.	-240.	183.	10.	75.	75.	0	1425.	1785.
AFT	50.	1895.	227.	183.	10.	64.	64.	0	1785.	2009.
AFT	50.	1895.	-227.	183.	10.	64.	64.	0	1785.	2009.

RIB 3

W= 1408.0	X=	1667.40	Y=	0.00	Z=	183.00
RAD OF GYRATION	KROLL=	239.31	KPIT=	97.35	KYAW=	258.16
MOM OF INERTIA	ROLL=	17404.	PITCH=	2880.	YAW=	20254.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIB 3A	50.	1895.	260.	184.	10.	64.	64.	0	1785.	2009.
RIB 3A	50.	1895.	-260.	184.	10.	64.	64.	0	1785.	2009.

RIB 3A

W= 100.0	X=	1895.00	Y=	0.00	Z=	184.00
RAD OF GYRATION	KROL=	260.19	KPIT=	64.00	KYAW=	267.76
MOM OF INERTIA	ROLL=	1461.	PITCH=	88.	YAW=	1547.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

FWD	92.	1600.	290.	185.	10.	75.	75.	0	1425.	1785.
FWD	92.	1600.	-290.	185.	10.	75.	75.	0	1425.	1785.
AFT	50.	1895.	290.	185.	10.	65.	65.	0	1785.	2009.
AFT	50.	1895.	-290.	185.	10.	65.	65.	0	1785.	2009.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

RIB 4

W= 284.0	X= 1703.87	Y= 0.00	Z= 185.00
RAD OF GYRATION	KROL= 290.17	KPIT= 158.07	KYAW= 330.28
MOM OF INERTIA	ROLL= 5161.	PITCH= 1532.	YAW= 6687.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -0.

FWD	59.	1690.	319.	185.	10.	53.	53.	0	1600.	1785.
FWD	59.	1690.	-319.	185.	10.	53.	53.	0	1600.	1785.
AFT	50.	1895.	319.	185.	10.	65.	65.	0	1785.	2009.
AFT	50.	1895.	-319.	185.	10.	65.	65.	0	1785.	2009.

RIB 4A

W= 218.0	X= 1784.04	Y= 0.00	Z= 185.00
RAD OF GYRATION	KROL= 319.16	KPIT= 117.87	KYAW= 340.08
MOM OF INERTIA	ROLL= 4793.	PITCH= 654.	YAW= 5442.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -0.

FWD	59.	1690.	349.	198.	10.	53.	53.	0	1600.	1785.
FWD	59.	1690.	-349.	198.	10.	53.	53.	0	1600.	1785.
AFT	154.	1920.	349.	198.	10.	65.	65.	0	1785.	2009.
AFT	154.	1920.	-349.	198.	10.	65.	65.	0	1785.	2009.

RIBS

W= 426.0	X= 1856.29	Y= 0.00	Z= 198.00
RAD OF GYRATION	KROL= 349.14	KPIT= 120.11	KYAW= 369.09
MOM OF INERTIA	ROLL= 11209.	PITCH= 1327.	YAW= 12526.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES

65K EASTERLY MISSION UNITS = INCH

RIB 5A	154.	1920.	364.	201.	10.	65.	65.	0	1785.	2009.
RIB 5A	154.	1920.	-364.	201.	10.	65.	65.	0	1785.	2009.

RIB 5A

W= 308.0	X=	1920.00	Y=	0.00	Z=	201.00
RAD OF GYRATION	KROLL=	364.14	KPIT=	65.00	KYAW=	369.76
MOM OF INERTIA	ROLL=	8815.	PITCH=	281.	YAW=	9089.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

FWD	23.	1735.	401.	206.	10.	43.	43.	0	1690.	1785.
FWD	23.	1735.	-401.	206.	10.	43.	43.	0	1690.	1785.
AFT	45.	1895.	401.	206.	10.	65.	65.	0	1785.	2009.
AFT	45.	1895.	-401.	206.	10.	65.	65.	0	1785.	2009.

RIB 5B

W= 136.0	X=	1840.88	Y=	0.00	Z=	206.00
RAD OF GYRATION	KROL=	401.12	KPIT=	95.66	KYAW=	412.25
MOM OF INERTIA	ROLL=	4723.	PITCH=	269.	YAW=	4989.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

FWD	10.	1755.	438.	216.	8.	36.	36.	0	1735.	1785.
FWD	10.	1755.	-438.	216.	8.	36.	36.	0	1735.	1785.
AFT	40.	1895.	438.	216.	8.	65.	65.	0	1785.	2009.
AFT	40.	1895.	-438.	216.	8.	65.	65.	0	1785.	2009.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

RIB 5C

```
W=      100.0     X=          1867.00   Y=            0.00   Z=          216.00
RAD OF GYRATION KROLL=         438.07   KPIT=        82.31   KYAW=       445.67
MOM OF INERTIA  ROLL=         4142.     PITCH=       146.    YAW=        4287.
PROD OF INERTIA ROL-PIT=         0.     PIT-YAW=       0.    YAW-ROL=       0.
```

RIB 5D	35.	1840.	481.	223.	6.	28.	28.	0	1815.	2009.
RIB 5D	35.	1840.	-481.	223.	6.	28.	28.	0	1815.	2009.

RIB 5D

```
W=       70.0     X=          1840.00   Y=            0.00   Z=          223.00
RAD OF GYRATION KROLL=         481.04   KPIT=        28.00   KYAW=       481.81
MOM OF INERTIA  ROLL=         3496.     PITCH=        12.    YAW=        3507.
PROD OF INERTIA ROL-PIT=         0.     PIT-YAW=       0.    YAW-ROL=       0.
```

RIB 6	30.	1930.	512.	227.	6.	28.	28.	0	1865.	2009.
RIB 6	30.	1930.	-512.	227.	6.	28.	28.	0	1865.	2009.

RIB 6

```
W=       60.0     X=          1930.00   Y=            0.00   Z=          227.00
RAD OF GYRATION KROLL=         512.03   KPIT=        28.00   KYAW=       512.76
MOM OF INERTIA  ROLL=         3395.     PITCH=        10.    YAW=        3405.
PROD OF INERTIA ROL-PIT=         0.     PIT-YAW=       0.    YAW-ROL=       0.
```

INBD OMS	38.	1969.	534.	230.	4.	26.	26.	0	1919.	2009.
INBD OMS	38.	1969.	-534.	230.	4.	26.	26.	0	1919.	2009.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

INBD OMS

W= 76.0	X= 1969.00	Y= 0.00	Z= 230.00
RAD OF GYRATION	KROLL= 534.01	KPIT= 26.00	KYAW= 534.63
MOM OF INERTIA	ROLL= 4678.	PITCH= 11.	YAW= 4689.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

OUTBD OMS	20.	1984.	554.	230.	4.	22.	22.	0	1949.	2009.
OUTBD OMS	20.	1984.	-554.	230.	4.	22.	22.	0	1949.	2009.

OUTBD OMS

W= 40.0	X= 1984.00	Y= 0.00	Z= 230.00
RAD OF GYRATION	KROLL= 554.01	KPIT= 22.00	KYAW= 554.44
MOM OF INERTIA	ROLL= 2650.	PITCH= 4.	YAW= 2654.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

UPR CT SKIN	222.	1897.	73.	176.	43.	65.	65.	0	1785.	2009.
UPR CT SKIN	222.	1897.	-73.	176.	43.	65.	65.	0	1785.	2009.
LWR CT SKIN	253.	1897.	73.	176.	43.	65.	65.	0	1785.	2009.
LWR CT SKIN	253.	1897.	-73.	176.	43.	65.	65.	0	1785.	2009.

CT SKIN

W= 950.0	X= 1897.00	Y= 0.00	Z= 176.00
RAD OF GYRATION	KROLL= 84.72	KPIT= 64.99	KYAW= 97.74
MOM OF INERTIA	ROLL= 1472.	PITCH= 866.	YAW= 1959.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES (INCHES)
65K EASTERLY MISSION UNITS = INCH										
UPR CT STGR	218.	1897.	73.	176.	43.	65.	65.	0	1785.	2009.
UPR CT STGR	218.	1897.	-73.	176.	43.	65.	65.	0	1785.	2009.
LWR CT STGR	170.	1897.	73.	176.	43.	65.	65.	0	1785.	2009.
LWR CT STGR	170.	1897.	-73.	176.	43.	65.	65.	0	1785.	2009.

CT STGR

W=	776.0	X=	1897.00	Y=	0.00	Z=	176.00
RAD OF GYRATION		KROLL=	84.72	KPIT=	65.00	KYAW=	97.74
MOM OF INERTIA		ROLL=	1202.	PITCH=	708.	YAW=	1600.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIB	123.	1897.	0.	176.	10.	43.	43.	0	1785.	2009.

BLO RIB

W=	123.0	X=	1897.00	Y=	0.00	Z=	176.00
RAD OF GYRATION		KROLL=	10.00	KPIT=	43.00	KYAW=	43.00
MOM OF INERTIA		ROLL=	3.	PITCH=	49.	YAW=	49.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIB	105.	1897.	28.	176.	10.	43.	43.	0	1785.	2009.
RIB	105.	1897.	-28.	176.	10.	43.	43.	0	1785.	2009.

BL 28 RIB

W=	210.0	X=	1897.00	Y=	0.00	Z=	176.00
RAD OF GYRATION		KROLL=	29.73	KPIT=	42.99	KYAW=	51.30
MOM OF INERTIA		ROLL=	40.	PITCH=	84.	YAW=	119.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

RIB	118.	1897.	55.	176.	10.	43.	43.	0	1785.	2009.
RIB	118.	1897.	-55.	176.	10.	43.	43.	0	1785.	2009.

BL 55 RIB

W=	236.0	X=	1897.00	Y=	0.00	Z=	176.00
RAD OF GYRATION		KROLL=	55.90	KPITCH=	42.99	KYAW=	69.81
MOM OF INERTIA		ROLL=	159.	PITCH=	94.	YAW=	248.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIB	106.	1897.	85.	176.	10.	43.	43.	0	1785.	2009.
RIB	106.	1897.	-85.	176.	10.	43.	43.	0	1785.	2009.

BL85 RIB

W=	212.0	X=	1897.00	Y=	0.00	Z=	176.00
RAD OF GYRATION		KROL=	85.59	KPIT=	43.00	KYAW=	95.26
MOM OF INERTIA		ROLL=	335.	PITCH=	85.	YAW=	415.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIB	114.	1897.	119.	176.	10.	43.	43.	0	1785.	2009.
RIB	114.	1897.	-119.	176.	10.	43.	43.	0	1785.	2009.

BL119 RIB

W=	228.0	X=	1897.00	Y=	0.00	Z=	176.00
RAD OF GYRATION		KROL=	119.42	KPIT=	42.99	KYAW=	126.53
MOM OF INERTIA		ROLL=	702.	PITCH=	91.	YAW=	788.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

C/C L.E.	818.	1663.	400.	187.	78.	137.	162.	0	1425.	1900.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
65K EASTERLY MISSION					UNITS - INCH					
C/CL•E•	818•	1663•	•400•	187•	78•	137•	162•	0	1425•	1900•
CB L•E•	255•	1961•	590•	237•	17•	35•	38•	0	1900•	2100•
CB L•E•	255•	1961•	-590•	237•	17•	35•	38•	0	1900•	2100•
CB STRAKE	1563•	1177•	180•	193•	29•	144•	150•	0	929•	1425•
CB STRAKE	1563•	1177•	-180•	193•	29•	144•	150•	0	929•	1425•

LEADING EDGE

W= 5272•0	X=	1403•66	Y=	0•00	Z=	195•39
RAD OF GYRATION	KROL=	324•26	KPIT=	315•93	KYAW=	453•37
MOM OF INERTIA	ROLL=	119644•	PITCH=	113580•	YAW=	233892•
PROD OF INERTIA	ROL-PIT=	0•	PIT-YAW=	0•	YAW-ROL=	2150•

MLG DOOR	259•	1692•	190•	185•	26•	54•	54•	0	1600•	1785•
MLG DOOR	259•	1692•	-190•	185•	26•	54•	54•	0	1600•	1785•

MLG DOORS

W= 518•0	X=	1692•00	Y=	0•00	Z=	185•00
RAD OF GYRATION	KROL=	191•77	KPIT=	54•00	KYAW=	197•52
MOM OF INERTIA	ROLL=	4112•	PITCH=	326•	YAW=	4362•
PROD OF INERTIA	ROL-PIT=	0•	PIT-YAW=	0•	YAW-ROL=	0•

ABES DOOR	442•	1510•	190•	185•	28•	54•	54•	0	1425•	1600•
ABES DOOR	442•	1510•	-190•	185•	28•	54•	54•	0	1425•	1600•
ABES DOOR	442•	1692•	290•	185•	28•	54•	54•	0	1600•	1785•
ABES DOOR	442•	1692•	-290•	185•	28•	54•	54•	0	1600•	1785•

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES

65K EASTERLY MISSION UNITS = INCH

ABES DOOR

W= 1768.0	X=	1601.00	Y=	0.00	Z=	185.00				
RAD OF GYRATION	KROLL=	246.75	KPIT=	105.82	KYAW=	267.02				
MOM OF INERTIA	ROLL=	23234.	PITCH=	4273.	YAW=	27208.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.				
UPR SKIN	376.	2087.	404.	197.	140.	43.	140.	0	2009.	2166.
UPR SKIN	376.	2087.	-404.	197.	140.	43.	140.	0	2009.	2166.
LWR SKIN	372.	2087.	404.	197.	140.	43.	140.	0	2009.	2166.
LWR SKIN	372.	2087.	-404.	197.	140.	43.	140.	0	2009.	2166.

SKIN

W= 1496.0	X=	2087.00	Y=	0.00	Z=	197.00				
RAD OF GYRATION	KROL=	427.57	KPIT=	43.00	KYAW=	427.57				
MOM OF INERTIA	ROLL=	59031.	PITCH=	597.	YAW=	59031.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.				
UPR STGR	136.	2087.	404.	197.	140.	43.	140.	0	2009.	2166.
UPR STGR	136.	2087.	-404.	197.	140.	43.	140.	0	2009.	2166.
LWR STGR	149.	2087.	404.	197.	140.	43.	140.	0	2009.	2166.
LWR STGR	149.	2087.	-404.	197.	140.	43.	140.	0	2009.	2166.

STGR

W= 570.0	X=	2087.00	Y=	0.00	Z=	197.00
RAD OF GYRATION	KROL=	427.57	KPIT=	43.00	KYAW=	427.57
MOM OF INERTIA	ROLL=	22492.	PITCH=	227.	YAW=	22492.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

SPAR	110.	2024.	404.	197.	140.	5.	140.	0	2022.	2026.
SPAR	110.	2024.	=404.	197.	140.	5.	140.	0	2022.	2026.

SPAR

W= 220.0	X=	2024.00	Y=	0.00	Z=	197.00
RAD OF GYRATION	KROLL=	427.57	KPIT=	4.88	KYAW=	427.57
MOM OF INERTIA	ROLL=	8681.	PITCH=	1.	YAW=	8681.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIBS	371.	2059.	404.	197.	140.	43.	140.	0	2009.	2166.
RIBS	371.	2059.	=404.	197.	140.	43.	140.	0	2009.	2166.

RIBS

W= 742.0	X=	2059.00	Y=	0.00	Z=	197.00
RAD OF GYRATION	KROL=	427.57	KPIT=	43.00	KYAW=	427.57
MOM OF INERTIA	ROLL=	29279.	PITCH=	296.	YAW=	29279.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

INTERCSTL	26.	2087.	404.	197.	140.	43.	140.	0	2009.	2166.
INTERCSTL	26.	2087.	=404.	197.	140.	43.	140.	0	2009.	2166.

INTERCSTL

W= 52.0	X=	2087.00	Y=	0.00	Z=	197.00
RAD OF GYRATION	KROL=	427.57	KPIT=	43.00	KYAW=	427.57
MOM OF INERTIA	ROLL=	2052.	PITCH=	21.	YAW=	2052.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

DOORS	185.	2020.	404.	197.	140.	43.	140.	0	2009.	2030.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS = INCH

DOORS	185.	2020.	-404.	197.	140.	43.	140.	0	2009.	2030.

DOORS

W= 370.0	X=	2020.00	Y=	0.00	Z=		197.00
RAD OF GYRATION	KROLL=	427.57	KPIT=	42.99	KYAW=		427.57
MOM OF INERTIA	ROLL=	14600.	PITCH=	148.	YAW=		14600.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		0.

HINGES	92.	2021.	404.	197.	140.	2.	140.	0	2009.	2030.
HINGES	92.	2021.	-404.	197.	140.	2.	140.	0	2009.	2030.

HINGES

W= 184.0	X=	2021.00	Y=	0.00	Z=		197.00
RAD OF GYRATION	KROLL=	427.57	KPIT=	1.62	KYAW=		427.57
MOM OF INERTIA	ROLL=	7260.	PITCH=	0.	YAW=		7260.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		-0.

CONTINGENCY	2872.	1738.	0.	194.	2.	2.	2.	0	929.	2166.

CONTINGENCY

W= 2872.0	X=	1738.00	Y=	0.00	Z=		194.00
RAD OF GYRATION	KROLL=	2.00	KPIT=	2.00	KYAW=		2.00
MOM OF INERTIA	ROLL=	2.	PITCH=	2.	YAW=		2.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - WING

W=	31587.0	X=	1737.98	Y=	.00	Z= 194.15
RAD OF GYRATION		KROL=	283.68	KPIT=	249.04	KYAW= 375.72
MOM OF INERTIA		ROLL=	548662.	PITCH=	422846.	YAW= 962420.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL= 3585.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

SKIN	743.	2028.	0.	623.	10.	83.	83.	0	1907.	2179.
STRIG	495.	2028.	0.	623.	10.	83.	83.	0	1907.	2179.

TB COVER

W= 1238.0	X=	2028.00	Y=	0.00	Z=	623.00
RAD OF GYRATION	KROL=	9.99	KPIT=	83.00	KYAW=	83.00
MOM OF INERTIA	ROLL=	27.	PITCH=	1841.	YAW=	1841.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

CAPS	203.	1984.	0.	623.	10.	78.	78.	0	1907.	2088.
WEBS	63.	1984.	0.	623.	10.	78.	78.	0	1907.	2088.

FRONT SPAR

W= 266.0	X=	1984.00	Y=	0.00	Z=	623.00
RAD OF GYRATION	KROL=	10.00	KPIT=	78.00	KYAW=	78.00
MOM OF INERTIA	ROLL=	6.	PITCH=	349.	YAW=	349.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

CAPS	220.	2035.	0.	623.	10.	78.	78.	0	1979.	2134.
WEB	80.	2035.	0.	623.	10.	78.	78.	0	1979.	2134.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

MID SPAR

W= 300.0	X= 2035.00	Y= 0.00	Z= 623.00
RAD OF GYRATION KROL=	10.00	KPIT=	77.99	KYAW=	77.99
MOM OF INERTIA ROLL=	6.	PITCH=	394.	YAW=	394.
PROD OF INERTIA ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

CAPS	172.	2094.	0.	623.	10.	78.	78.	0	2049.	2179.
WEB	57.	2094.	0.	623.	10.	78.	78.	0	2049.	2179.

REAR SPAR

W= 229.0	X= 2094.00	Y= 0.00	Z= 623.00
RAD OF GYRATION KROL=	10.00	KPIT=	78.00	KYAW=	78.00
MOM OF INERTIA ROLL=	5.	PITCH=	301.	YAW=	301.
PROD OF INERTIA ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIB1	17.	1952.	0.	526.	10.	34.	34.	0	1907.	2179.
RIB2	26.	1986.	0.	530.	10.	34.	34.	0	1907.	2179.
RIB3	31.	1997.	0.	545.	10.	33.	33.	0	1907.	2179.
RIB4	30.	2006.	0.	563.	9.	33.	33.	0	1907.	2179.
RIB5	28.	2022.	0.	599.	9.	32.	32.	0	1907.	2179.
RIB6	27.	2030.	0.	617.	9.	32.	32.	0	1907.	2179.
RIB7	26.	2038.	0.	635.	8.	31.	31.	0	1907.	2179.
RIB8	25.	2047.	0.	653.	8.	30.	30.	0	1907.	2179.
RIB9	24.	2055.	0.	671.	8.	30.	30.	0	1907.	2179.
RIB10	21.	2082.	0.	728.	7.	29.	29.	0	1907.	2179.
RIB11	20.	2090.	0.	747.	7.	28.	28.	0	1907.	2179.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

RIB12	19.	2099.	0.	767.	7.	27.	27.	0	1907.	2179.
RIB13	18.	2108.	0.	785.	6.	27.	27.	0	1907.	2179.
RIB14	16.	2125.	0.	825.	6.	26.	26.	0	1907.	2179.
RIB15	9.	2155.	0.	835.	6.	26.	26.	0	1907.	2179.

INTER RIBS

W= 337.0	X=	2043.20	Y=	0.00	Z=	648.44
RAD OF GYRATION	KROLL=	95.11	KPITCH=	110.68	KYAW=	57.21
MOM OF INERTIA	ROLL=	658.	PITCH=	891.	YAW=	238.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=	328.

CAP RIB	18.	2134.	0.	842.	6.	26.	26.	0	1907.	2179.

CAP RIB

W= 18.0	X=	2134.00	Y=	0.00	Z=	842.00
RAD OF GYRATION	KROLL=	6.00	KPITCH=	26.00	KYAW=	26.00
MOM OF INERTIA	ROLL=	0.	PITCH=	3.	YAW=	3.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=	0.

UPR HINGE	19.	2130.	0.	805.	7.	29.	29.	0	1907.	2179.

HINGE RIB

W= 19.0	X=	2130.00	Y=	0.00	Z=	805.00
RAD OF GYRATION	KROLL=	7.00	KPITCH=	29.00	KYAW=	29.00
MOM OF INERTIA	ROLL=	0.	PITCH=	3.	YAW=	3.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=	0.

LWR HINGE	35.	2025.	0.	581.	9.	33.	33.	0	1907.	2179.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

HINGE RIB

W= 35.0	X= 2025.00	Y= 0.00	Z= 581.00		
RAD OF GYRATION	KROLL= 9.00	KPIT= 33.00	KYAW= 33.00		
MOM OF INERTIA	ROLL= 1.	PITCH= 8.	YAW= 8.		
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.		

UPR DRIVE	29.	2076.	0.	709.	8.	30.	30.	0	1907.	2179.

DRIVE RIB

W= 29.0	X= 2076.00	Y= 0.00	Z= 709.00		
RAD OF GYRATION	KROLL= 8.00	KPIT= 30.00	KYAW= 30.00		
MOM OF INERTIA	ROLL= 0.	PITCH= 6.	YAW= 6.		
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.		

LWR DRIVE	31.	2070.	0.	690.	8.	30.	30.	0	1907.	2179.

DRIVE RIB

W= 31.0	X= 2070.00	Y= 0.00	Z= 690.00		
RAD OF GYRATION	KROLL= 8.00	KPIT= 30.00	KYAW= 30.00		
MOM OF INERTIA	ROLL= 0.	PITCH= 6.	YAW= 6.		
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.		

ROOT RIB	147.	1985.	0.	508.	10.	33.	33.	0	1907.	2179.

ROOT RIB

W= 147.0	X= 1985.00	Y= 0.00	Z= 508.00		
RAD OF GYRATION	KROLL= 10.00	KPIT= 33.00	KYAW= 33.00		
MOM OF INERTIA	ROLL= 3.	PITCH= 35.	YAW= 36.		
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.		

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

CLOSE OUT	12.	2130.	0.	650.	8.	11.	93.	0	2049.	2264.
SKIN	522.	2170.	0.	650.	8.	11.	93.	0	2049.	2264.
STR'G	351.	2130.	0.	650.	8.	11.	93.	0	2049.	2264.

COVER

W= 885.0	X=	2153.59	Y=	0.00	Z=	650.00
RAD OF GYRATION	KROL=	8.00	KPIT=	22.58	KYAW=	95.07
MOM OF INERTIA	ROLL=	12.	PITCH=	97.	YAW=	1726.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

CAPS	35.	2130.	0.	650.	8.	11.	93.	0	2070.	2194.
WEB	52.	2130.	0.	650.	8.	11.	93.	0	2070.	2194.

FRONT SPAR

W= 87.0	X=	2130.00	Y=	0.00	Z=	650.00
RAD OF GYRATION	KROL=	8.00	KPIT=	11.00	KYAW=	93.00
MOM OF INERTIA	ROLL=	1.	PITCH=	2.	YAW=	162.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RIB4	3.	2087.	0.	526.	6.	11.	11.	0	2070.	2264.
RIB5	9.	2115.	0.	553.	6.	11.	11.	0	2070.	2264.
RIB6	11.	2125.	0.	573.	6.	11.	11.	0	2070.	2264.
RIB7	11.	2135.	0.	591.	6.	11.	11.	0	2070.	2264.
RIB8	11.	2145.	0.	606.	6.	11.	11.	0	2070.	2264.
RIB9	10.	2150.	0.	625.	6.	11.	11.	0	2070.	2264.
RIB10	9.	3175.	0.	687.	6.	11.	11.	0	2070.	2264.
RIB11	9.	2180.	0.	707.	6.	11.	11.	0	2070.	2264.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

RIB12	8.	2185.	0.	727.	6.	11.	11.	0	2070.	2264.
RIB13	8.	2190.	0.	747.	6.	11.	11.	0	2070.	2264.
RIB14	7.	2205.	0.	787.	6.	11.	11.	0	2070.	2264.
RIB15	7.	2210.	0.	807.	6.	11.	11.	0	2070.	2264.
RIB16	6.	2220.	0.	837.	6.	11.	11.	0	2070.	2264.

INTER RIBS

W= 109.0	X=	2244.69	Y=	0.00	Z= 667.83
RAD OF GYRATION	KROLL=	91.33	KPIT=	295.77	KYAW= 281.38
MOM OF INERTIA	ROLL=	196.	PITCH=	2058.	YAW= 1863.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL= 110.

UPR CAP	6.	2220.	0.	842.	6.	11.	11.	0	2194.	2194.
LWR CAP	19.	2130.	0.	534.	8.	11.	11.	0	2070.	2182.

CAP RIBS

W= 25.0	X=	2151.60	Y=	0.00	Z= 607.92
RAD OF GYRATION	KROL=	131.76	KPIT=	137.49	KYAW= 40.00
MOM OF INERTIA	ROLL=	94.	PITCH=	102.	YAW= 9.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL= 27.

LWR DRIVE	21.	2155.	0.	647.	6.	11.	11.	0	2070.	2264.

DRIVE RIB

W= 21.0	X=	2155.00	Y=	0.00	Z= 647.00
RAD OF GYRATION	KROL=	6.00	KPIT=	11.00	KYAW= 11.00
MOM OF INERTIA	ROLL=	0.	PITCH=	1.	YAW= 1.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL= 0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

UPR HINGE	10.	2200.	0.	766.	6.	11.	11.	0	2070.	2264.

HINGE RIB

W= 10.0	X=	2200.00	Y=	0.00	Z=	766.00
RAD OF GYRATION	KROL=	6.00	KPIT=	11.00	KYAW=	11.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

LWR HINGE	6.	2015.	0.	541.	6.	11.	11.	0	2070.	2264.

HINGE RIB

W= 6.0	X=	2015.00	Y=	0.00	Z=	541.00
RAD OF GYRATION	KROL=	6.00	KPIT=	11.00	KYAW=	11.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

UPR DRIVE	21.	2165.	0.	667.	6.	11.	11.	0	2070.	2264.

DRIVE RIB

W= 21.0	X=	2165.00	Y=	0.00	Z=	667.00
RAD OF GYRATION	KROL=	6.00	KPIT=	11.00	KYAW=	11.00
MOM OF INERTIA	ROLL=	0.	PITCH=	1.	YAW=	1.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

HINGE	24.	2164.	0.	783.	2.	2.	2.	0	2160.	2168.
HINGE	24.	2127.	0.	683.	2.	2.	2.	0	2123.	2131.
HINGE	24.	2120.	0.	664.	2.	2.	2.	0	2116.	2124.
HINGE	24.	2075.	0.	553.	2.	2.	2.	0	2071.	2079.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

HINGE FTG

W= 96.0	X=	2121.50	Y=	0.00	Z=	670.75		
RAD OF GYRATION	KROL=	81.66	KPIT=	87.57	KYAW=	31.69		
MOM OF INERTIA	ROLL=	138.	PITCH=	159.	YAW=	21.		
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	53.		

LEADING EDGE	731.	1970.	0.	623.	10.	83.	83.	0	1865.	2088.

LEADING EDGE

W= 731.0	X=	1970.00	Y=	0.00	Z=	623.00		
RAD OF GYRATION	KROL=	10.00	KPIT=	83.00	KYAW=	83.00		
MOM OF INERTIA	ROLL=	16.	PITCH=	1087.	YAW=	1087.		
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.		

CONT'G	464.	2056.	0.	632.	2.	2.	2.	0	1865.	2264.

CONT'G

W= 464.0	X=	2056.00	Y=	0.00	Z=	632.00		
RAD OF GYRATION	KROL=	2.00	KPIT=	2.00	KYAW=	2.00		
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.		
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.		

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - TAILS

W=	5104.0	X=	2054.50	Y=	.00	Z=	631.63
RAD OF GYRATION		KROL=	45.51	KPIT=	100.33	KYAW=	98.47
MOM OF INERTIA		ROLL=	2282.	PITCH=	11090.	YAW=	10683.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	1666.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
FWD LOX BKHD	74.	285.	25.	228.	28.	20.	20.	0	370.	395.
FWD LOX BKHD	74.	285.	-25.	228.	28.	20.	20.	0	370.	395.
R LOX TANK	2835.	744.	45.	228.	70.	160.	160.	0	395.	950.
L LOX TANK	2835.	744.	-45.	228.	70.	160.	160.	0	395.	950.
R LOX BFL	112.	744.	45.	228.	60.	160.	160.	0	395.	950.
L LOX BFL	112.	744.	-45.	228.	60.	160.	160.	0	395.	950.

LOX TANK

W= 6042.0	X=	732.76	Y=	0.00	Z=	228.00
RAD OF GYRATION	KROLL=	82.11	KPITCH=	173.25	KYAW=	178.91
MOM OF INERTIA	ROLL=	8792.	PITCH=	39146.	YAW=	41742.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

AFT LH2 BKHD	294.	1730.	55.	226.	59.	41.	41.	0	1710.	1770.
AFT LH2 BKHD	294.	1730.	-55.	226.	59.	41.	41.	0	1710.	1770.
R LH2 TANK	4432.	1348.	55.	226.	83.	220.	220.	0	950.	1710.
L LH2 TANK	4432.	1348.	-55.	226.	83.	220.	220.	0	950.	1710.
R LH2 BFL	141.	1348.	55.	226.	73.	220.	220.	0	950.	1710.
L LH2 BFL	141.	1348.	-55.	226.	73.	220.	220.	0	950.	1710.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS • INCH

LH2 TANK

W= 9734.0	X=	1371.08	Y=	0.00	Z=	226.00
RAD OF GYRATION	KROLL=	98.30	KPIT=	232.08	KYAW=	238.51
MOM OF INERTIA	ROLL=	20302.	PITCH=	113159.	YAW=	119514.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

CMN BKHD R	1438.	929.	55.	226.	59.	41.	41.	0	880.	950.
CMN BKHD L	1438.	929.	-55.	226.	59.	41.	41.	0	880.	950.

COMMON BKHD

W= 2876.0	X=	929.00	Y=	0.00	Z=	226.00
RAD OF GYRATION	KROLL=	80.66	KPIT=	41.00	KYAW=	68.60
MOM OF INERTIA	ROLL=	4039.	PITCH=	1043.	YAW=	2921.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

R LH2 INS	998.	1348.	55.	226.	83.	220.	220.	0	950.	1710.
L LH2 INS	998.	1348.	-55.	226.	83.	220.	220.	0	950.	1710.

LH2 INSUL

W= 1996.0	X=	1348.00	Y=	0.00	Z=	226.00
RAD OF GYRATION	KROLL=	99.57	KPIT=	220.00	KYAW=	226.77
MOM OF INERTIA	ROLL=	4271.	PITCH=	20852.	YAW=	22155.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

TANK RINGS R	503.	787.	45.	228.	48.	200.	200.	0	387.	1076.
TANK RINGS L	503.	787.	-45.	228.	48.	200.	200.	0	387.	1076.
FRAMES R	829.	873.	80.	350.	55.	130.	130.	0	613.	1076.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
FRAMES L	829.	873.	-80.	350.	55.	130.	130.	0	613.	1076.
RINGS&FRAMES										
W= 2664.0	X=	840.52	Y=	0.00	Z=	303.93				
RAD OF GYRATION	KROLL=	104.88	KPIT=	175.67	KYAW=	179.19				
MOM OF INERTIA	ROLL=	6324.	PITCH=	17744.	YAW=	18463.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	1418.				
LONGERON R	350.	851.	83.	396.	1.	115.	115.	0	613.	1076.
LONGERON L	350.	851.	-83.	396.	1.	115.	115.	0	613.	1076.
LONGERONS										
W= 700.0	X=	851.00	Y=	0.00	Z=	396.00				
RAD OF GYRATION	KROLL=	83.01	KPIT=	115.00	KYAW=	141.82				
MOM OF INERTIA	ROLL=	1041.	PITCH=	1998.	YAW=	3039.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.				
TANK EXT R	391.	307.	35.	225.	40.	46.	46.	0	227.	387.
TANK EXT L	391.	307.	-35.	225.	40.	46.	46.	0	227.	387.
UPR SKIN	400.	986.	0.	470.	50.	110.	110.	0	886.	1076.
SHEAR PNL R	373.	846.	80.	350.	55.	130.	130.	0	613.	1076.
SHEAR PNL L	373.	846.	-80.	350.	55.	130.	130.	0	613.	1076.
SIDEWALL										
W= 1928.0	X=	656.43	Y=	0.00	Z=	324.20				
RAD OF GYRATION	KROLL=	118.20	KPIT=	323.31	KYAW=	314.40				
MOM OF INERTIA	ROLL=	5814.	PITCH=	43499.	YAW=	41133.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	10787.				

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

LONGERON R	527.	1525.	100.	425.	1.	230.	230.	0	1076.	1865.
LONGERON L	527.	1525.	-100.	425.	1.	230.	230.	0	1076.	1865.

LONGERONS

W= 1054.0	X=	1525.00	Y=	0.00	Z=	425.00
RAD OF GYRATION	KROL=	100.00	KPIT=	230.00	KYAW=	250.80
MOM OF INERTIA	ROLL=	2275.	PITCH=	12035.	YAW=	14309.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SHEAR PNL R	688.	1500.	125.	325.	55.	230.	230.	0	1076.	1865.
SHEAR PNL L	688.	1500.	-125.	325.	55.	230.	230.	0	1076.	1865.
TANK EXT R	595.	1785.	55.	226.	83.	45.	45.	0	1710.	1865.
TANK EXT L	595.	1785.	-55.	226.	83.	45.	45.	0	1710.	1865.

SIDEWALL

W= 2566.0	X=	1632.17	Y=	0.00	Z=	279.09
RAD OF GYRATION	KROL=	130.52	KPIT=	227.91	KYAW=	243.49
MOM OF INERTIA	ROLL=	9435.	PITCH=	28768.	YAW=	32836.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-3886.

FRAMES R	1422.	1461.	125.	325.	83.	230.	230.	0	1076.	1865.
FRAMES L	1422.	1461.	-125.	325.	83.	230.	230.	0	1076.	1865.
RINGS R	535.	1446.	55.	226.	83.	230.	230.	0	1076.	1865.
RINGS L	535.	1446.	-55.	226.	83.	230.	230.	0	1076.	1865.
1076 BKHD	636.	1076.	0.	226.	70.	70.	70.	0	1075.	1077.
1425 BKHD	472.	1425.	0.	226.	70.	70.	70.	0	1472.	1428.
1785 BKHD	557.	1785.	0.	226.	70.	70.	70.	0	1784.	1786.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
1600 BKHD	349.	1600.	0.	226.	70.	70.	70.	0	1592.	1603.
FRAMES										
W= 5928.0	X=	1452.75	Y=	0.00	Z=	273.50				
RAD OF GYRATION	KROL=	129.23	KPIT=	256.94	KYAW=	267.60				
MOM OF INERTIA	ROLL=	21370.	PITCH=	84468.	YAW=	91628.				
PROD OF INERTIA	ROL*PIT=	0.	PIT*YAW=	0.	YAW*ROL=	502.				
SIDEWALL	1641.	1970.	0.	350.	100.	100.	100.	0	1865.	2100.
SHELL	175.	2050.	0.	450.	20.	20.	20.	0	1865.	2100.
DECK	289.	2005.	0.	425.	20.	20.	20.	0	1865.	2100.
SIDEWALL										
W= 2105.0	X=	1981.46	Y=	0.00	Z=	368.61				
RAD OF GYRATION	KROL=	95.61	KPIT=	98.54	KYAW=	91.94				
MOM OF INERTIA	ROLL=	4153.	PITCH=	4411.	YAW=	3840.				
PROD OF INERTIA	ROL*PIT=	0.	PIT*YAW=	0.	YAW*ROL=	369.				
1865 BKHD	1175.	1865.	0.	350.	100.	100.	100.	0	1864.	1866.
1901 FRAME	96.	1901.	0.	350.	100.	100.	100.	0	1900.	1902.
1937 BKHD	465.	1937.	0.	350.	100.	100.	100.	0	1936.	1938.
2009 BKHD	721.	2009.	0.	350.	100.	100.	100.	0	2004.	2006.
2049 BKHD	349.	2049.	0.	350.	100.	100.	100.	0	2004.	2006.
1865 CANTED	206.	1880.	0.	425.	20.	20.	20.	0	1865.	1900.
1937 CANTED	152.	1920.	0.	425.	20.	20.	20.	0	1900.	1937.
1971 FRAME	96.	1971.	0.	350.	100.	100.	100.	0	1968.	1981.
2100 BKHD	349.	2080.	0.	350.	100.	100.	100.	0	2060.	2100.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS = INCH

FRAMES

W= 3609.0	X= 1948.58	Y= 0.00	Z= 357.44
RAD OF GYRATION KROLL=	97.72	KPITCH=	124.86	KYAW=	122.83
MOM OF INERTIA ROLL=	7439.	PITCH=	12144.	YAW=	11753.
PROD OF INERTIA ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-299.

THRUST POST	1270.	1900.	0.	300.	75.	75.	75.	0	1865.	1930.

THRUST POST

W= 1270.0	X= 1900.00	Y= 0.00	Z= 300.00
RAD OF GYRATION KROLL=	75.00	KPITCH=	75.00	KYAW=	75.00
MOM OF INERTIA ROLL=	1542.	PITCH=	1542.	YAW=	1542.
PROD OF INERTIA ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

PAYLOAD DOOR	1819.	1471.	0.	470.	57.	230.	230.	0	1076.	1865.
DOOR MECH	1051.	1471.	0.	470.	57.	230.	230.	0	1076.	1865.
ACCESS DOOR	448.	750.	0.	370.	50.	78.	78.	0	613.	886.

DOORS

W= 3318.0	X= 1373.65	Y= 0.00	Z= 456.50
RAD OF GYRATION KROLL=	65.70	KPITCH=	329.33	KYAW=	327.55
MOM OF INERTIA ROLL=	3091.	PITCH=	77673.	YAW=	76837.
PROD OF INERTIA ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	6031.

WINDSHIELD	385.	920.	0.	480.	25.	25.	25.	0	900.	950.
CREW CAB	548.	990.	0.	430.	50.	50.	50.	0	890.	1065.
AIRLOCK	625.	990.	0.	480.	50.	50.	50.	0	890.	1065.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS • INCH

HATCHES	241.	990.	0.	480.	10.	10.	10.	0	890.	1065.
CREW CPT										
W= 1799.0	X=	975.02	Y=	0.00	Z=	464.77				
RAD OF GYRATION	KROL=	48.03	KPIT=	55.96	KYAW=	51.01				
MOM OF INERTIA	ROLL=	896.	PITCH=	1216.	YAW=	1010.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-88.				
FWD CPT	507.	504.	0.	470.	5.	5.	5.	0	395.	613.
AFT CPT	124.	1875.	0.	275.	25.	25.	25.	0	1800.	1950.
EQUIP CPT										
W= 631.0	X=	773.42	Y=	0.00	Z=	431.68				
RAD OF GYRATION	KROL=	78.40	KPIT=	550.39	KYAW=	544.91				
MOM OF INERTIA	ROLL=	837.	PITCH=	41258.	YAW=	40440.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-5749.				
SPEED BRK	534.	1950.	0.	340.	5.	5.	5.	0	1905.	1995.
SPEED BRK										
W= 534.0	X=	1950.00	Y=	0.00	Z=	340.00				
RAD OF GYRATION	KROL=	5.00	KPIT=	5.00	KYAW=	5.00				
MOM OF INERTIA	ROLL=	3.	PITCH=	3.	YAW=	3.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
N G ATTCH	330.	315.	0.	200.	5.	5.	5.	0	235.	395.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

STR PROV

W= 330.0	X=	315.00	Y=	0.00	Z=	200.00
RAD OF GYRATION	KROLL=	5.00	KPIT=	5.00	KYAW=	5.00
MOM OF INERTIA	ROLL=	2.	PITCH=	2.	YAW=	2.
PROD OF INERTIA	ROL=PIT=	0.	PIT=YAW=	0.	YAW=ROL=	0.

INTERSTAGE	1370.	1423.	0.	150.	5.	200.	200.	0	1076.	1770.

INTERSTAGE

W= 1370.0	X=	1423.00	Y=	0.00	Z=	150.00
RAD OF GYRATION	KROLL=	5.00	KPIT=	200.00	KYAW=	200.00
MOM OF INERTIA	ROLL=	7.	PITCH=	11828.	YAW=	11828.
PROD OF INERTIA	ROL=PIT=	0.	PIT=YAW=	0.	YAW=ROL=	0.

CONTIG	5046.	1293.	0.	289.	126.	465.	461.	0	177.	2100.

CONTIG

W= 5046.0	X=	1293.00	Y=	0.00	Z=	289.00
RAD OF GYRATION	KROLL=	126.00	KPIT=	465.00	KYAW=	461.00
MOM OF INERTIA	ROLL=	17291.	PITCH=	235497.	YAW=	231463.
PROD OF INERTIA	ROL=PIT=	0.	PIT=YAW=	0.	YAW=ROL=	0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - BODY

W=	55500.0	X=	1291.51	Y=	-.00	Z= 291.12
RAD OF GYRATION		KROL=	126.33	KPIT=	466.36	KYAW= 461.49
MOM OF INERTIA		ROLL=	191176.	PITCH=	2605368.	YAW= 2551287.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL= 82174.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS • INCH

NOSE CAP	350.	210.	0.	215.	28.	24.	24.	0	177.	227.

NOSE CAP

W= 350.0	X=	210.00	Y=	0.00	Z=	215.00
RAD OF GYRATION	KROL=	28.00	KPIT=	24.00	KYAW=	24.00
MOM OF INERTIA	ROLL=	59.	PITCH=	44.	YAW=	44.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=	0.

CB3•13	1313.	319.	0.	200.	29.	52.	75.	0	227.	400.
CB13•35	4378.	630.	0.	160.	90.	130.	295.	0	400.	84.
CB35•63	756.	1082.	0.	137.	94.	162.	188.	0	84.	1400.
HAST35•63	2801.	1082.	0.	137.	94.	162.	188.	0	900.	1400.
HAST63•87	3135.	1632.	0.	137.	94.	135.	165.	0	1400.	1865.
HAST87•100	791.	1982.	0.	137.	94.	68.	113.	0	1865.	2013.

BODY BTM

W= 13174.0	X=	1040.67	Y=	0.00	Z=	150.92
RAD OF GYRATION	KROL=	90.40	KPIT=	512.63	KYAW=	539.54
MOM OF INERTIA	ROLL=	23237.	PITCH=	747247.	YAW=	827733.
PROD OF INERTIA	ROL•PIT=	0.	PIT•YAW=	0.	YAW•ROL=	-21810.

RENE	971.	727.	150.	200.	104.	304.	304.	0	227.	1274.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

RENE	971.	727.	-150.	200.	104.	304.	304.	0	227.	1274.
INCONEL	634.	689.	150.	376.	86.	159.	159.	0	460.	1005.
INCONEL	634.	689.	-150.	376.	86.	159.	159.	0	460.	1005.
TITANIUM	617.	1417.	162.	250.	84.	304.	304.	0	886.	1865.
TITANIUM	617.	1417.	-162.	250.	84.	304.	304.	0	886.	1865.
HOT STR	281.	1420.	162.	400.	72.	423.	423.	0	657.	2100.
HOT STR	281.	1420.	-162.	400.	72.	423.	423.	0	657.	2100.
HOT STR	181.	1420.	162.	400.	72.	423.	423.	0	657.	2100.
HOT STR	182.	1420.	-162.	400.	72.	423.	423.	0	657.	2100.

SIDE&TOP

W= 5369.0	X=	996.01	Y=	-0.03	Z=	287.51
RAD OF GYRATION	KROLL=	198.25	KPIT=	467.69	KYAW=	485.40
MOM OF INERTIA	ROLL=	45545.	PITCH=	253474.	YAW=	273038.
PROD OF INERTIA	ROL-PIT=	-15.	PIT-YAW=	-4.	YAW-ROL=	7748.

HAST=80%	2124.	1772.	319.	150.	136.	217.	260.	0	1274.	2000.
HAST=80%	2124.	1772.	-319.	150.	136.	217.	260.	0	1274.	2000.
HAST=20%	575.	1772.	319.	150.	136.	217.	260.	0	1274.	2000.
HAST=20%	575.	1772.	-319.	150.	136.	217.	260.	0	1274.	2000.

WING BTM

W= 5398.0	X=	1772.00	Y=	0.00	Z=	150.00
RAD OF GYRATION	KROLL=	346.78	KPIT=	217.00	KYAW=	411.53
MOM OF INERTIA	ROLL=	140112.	PITCH=	54862.	YAW=	197322.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
65K EASTERLY MISSION UNITS • INCH										
ELEVON•CB	1466•	2094•	397•	183•	136•	44•	145•	0	2025•	2165•
ELEVON•CB	1466•	2094•	•397•	183•	136•	44•	145•	0	2025•	2165•
ELEVON										
W• 2932•0	X•	2094•00	Y•	0•00	Z•	183•00				
RAD OF GYRATION	KROL•	419•65	KPIT•	44•00	KYAW•	422•65				
MOM OF INERTIA	ROLL•	111447•	PITCH•	1225•	YAW•	113047•				
PROD OF INERTIA	ROL•PIT•	0•	PIT•YAW•	0•	YAW•ROL•	0•				
BODY FLAP	752•	2086•	0•	146•	94•	48•	101•	0	2006•	2166•
BODY FLAP										
W• 752•0	X•	2086•00	Y•	0•00	Z•	146•00				
RAD OF GYRATION	KROL•	94•00	KPIT•	48•00	KYAW•	101•00				
MOM OF INERTIA	ROLL•	1434•	PITCH•	374•	YAW•	1656•				
PROD OF INERTIA	ROL•PIT•	0•	PIT•YAW•	0•	YAW•ROL•	0•				
BASE	1100•	2100•	0•	332•	115•	107•	64•	0	1900•	2166•
BASE•ENG	526•	2100•	0•	332•	115•	107•	64•	0	1900•	2166•
BASE•ENG IMP	260•	2190•	0•	340•	104•	92•	93•	0	2166•	2230•
BASE										
W• 1886•0	X•	2112•41	Y•	0•00	Z•	333•10				
RAD OF GYRATION	KROL•	113•58	KPIT•	109•58	KYAW•	75•40				
MOM OF INERTIA	ROLL•	5252•	PITCH•	4888•	YAW•	2315•				
PROD OF INERTIA	ROL•PIT•	0•	PIT•YAW•	0•	YAW•ROL•	35•				
CONTINGENCY	2986•	1353•	0•	191•	234•	621•	661•	0	177•	2166•

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

CONTINGENCY

W=	2986.0	X=	1353.00	Y=	0.00	Z= 191.00
RAD OF GYRATION	KROL=	234.00	KPIT=	621.00	KYAW=	661.00
MOM OF INERTIA	ROLL=	35290.	PITCH=	248545.	YAW=	281595.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - THERMAL PROT

W=	32847.0	X=	1352.59	Y=	-.00	Z= 190.63
RAD OF GYRATION	KROL=	234.04	KPIT=	621.04	KYAW=	660.67
MOM OF INERTIA	ROLL=	388328.	PITCH=	2734395.	YAW=	3094534.
PROD OF INERTIA	ROL-PIT=	-2.	PIT-YAW=	-7.	YAW-ROL=	-5627.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

MAIN STRT R	1065.	1612.	198.	88.	39.	39.	17.	0	1600.	1710.
MAIN STRUT L	1065.	1612.	-198.	88.	39.	39.	17.	0	1600.	1710.
MAIN AXLE RH	127.	1610.	198.	29.	9.	9.	16.	0	1600.	1620.
MAIN AXLE LH	127.	1610.	-198.	29.	9.	9.	16.	0	1600.	1620.
ATT FTG RH	137.	1614.	198.	151.	25.	5.	25.	0	1600.	1628.
ATT FTG LH	137.	1614.	-198.	151.	25.	5.	25.	0	1600.	1628.
WHL INBD RH	182.	1610.	183.	29.	16.	20.	16.	0	1580.	1640.
WHL INBD LH	182.	1610.	-183.	29.	16.	20.	16.	0	1580.	1640.
WHL OUTBD RH	182.	1610.	214.	29.	16.	20.	16.	0	1580.	1640.
WHL OUTBD LH	182.	1610.	-214.	29.	16.	20.	16.	0	1580.	1640.
BKE OUTBD RH	303.	1610.	183.	29.	16.	20.	16.	0	1580.	1640.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
BKE INBD LH	303.	1610.	-183.		29.	16.	20.	16.	0 1580.	1640.
BKE BUTBD RH	303.	1610.	214.		29.	16.	20.	16.	0 1580.	1640.
BKE BUTBD LH	303.	1610.	-214.		29.	16.	20.	16.	0 1580.	1640.
TIRE INBD RH	263.	1610.	183.		29.	16.	20.	16.	0 1580.	1640.
TIRE INBD LH	263.	1610.	-183.		29.	16.	20.	16.	0 1580.	1640.
TIRE BUTBD R	263.	1610.	214.		29.	16.	20.	16.	0 1580.	1640.
TIRE BUTBD L	263.	1610.	-214.		29.	16.	20.	16.	0 1580.	1640.
AIR INBD RH	20.	1610.	183.		29.	16.	20.	16.	0 1580.	1640.
AIR INBD LH	20.	1610.	-183.		29.	16.	20.	16.	0 1580.	1640.
AIR BUTBD RH	20.	1610.	214.		29.	16.	20.	16.	0 1580.	1640.
AIR BUTBD LH	20.	1610.	-214.		29.	16.	20.	16.	0 1580.	1640.
CONTROL RH	422.	1612.	198.		29.	16.	20.	16.	0 1600.	1710.
CONTROL LH	422.	1612.	-198.		29.	16.	20.	16.	0 1600.	1710.
ANTI SKID RH	25.	1610.	198.		29.	16.	20.	16.	0 1580.	1640.
ANTI SKID LH	25.	1610.	-198.		29.	16.	20.	16.	0 1580.	1640.

MAIN GEAR EX

W= 6624.0	X=	1611.06	Y=	0.00	Z=	53.02
RAD OF GYRATION	KROL=	203.07	KPIT=	43.43	KYAW=	199.21
MOM OF INERTIA	ROLL=	58957.	PITCH=	2697.	YAW=	56739.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	46.

NG STRUT	480.	381.	0.	121.	50.	39.	39.	0	365.	395.
NG AXLE	30.	371.	0.	64.	50.	1.	50.	0	365.	375.
ATT FTG NG	53.	390.	0.	178.	50.	3.	50.	0	380.	400.
WHL RH NG	29.	371.	9.	64.	11.	10.	11.	0	350.	390.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES (INCHES)
65K EASTERLY MISSION UNITS = INCH										
WHL LH NG	29.	371.	-9.	64.	11.	10.	11.	0	350.	390.
TIRE RH NG	56.	371.	9.	64.	11.	10.	11.	0	350.	390.
TIRE LH NG	56.	371.	-9.	64.	11.	10.	11.	0	350.	390.
AIR RH NG	3.	371.	9.	64.	11.	10.	11.	0	350.	390.
AIR LH NG	3.	371.	-9.	64.	11.	10.	11.	0	350.	390.
CONTROLS	237.	381.	0.	121.	50.	39.	39.	0	365.	390.
NOSE GEAR EX										
W= 976.0	X= 379.38	Y= 0.00	Z= 112.06							
RAD OF GYRATION	KROL= 53.55	KPIT= 44.06	KYAW= 37.27							
MOM OF INERTIA	ROLL= 604.	PITCH= 409.	YAW= 293.							
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 28.							
PRES SYS	36.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
EXT RET VLVS	18.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
SHK ABS/ACT	26.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
HYD FLD ABS/	10.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
PLUMBING	10.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
VENT VLVS	15.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
CIRCUITRY	10.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
ACT RIGID 2	20.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
LATCHES RIGD	12.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
DRIVE SYS	18.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
LATCH CAPT	4.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
ACT-CAP LAT	4.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
INFL SEAL	10.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
ALIGN GUIDS	2.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
STRUCTUREADP	140.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
DOCK RING	41.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
INDICATOR	2.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
SWITCHES	1.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
VENT CONTROL	2.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
EXT RET SW	1.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
ACPS CONTROL	10.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
RELAY PNL	5.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
CIRC	3.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
DOCKING ADP										
W= 400.0	X=	1107.00	Y=	0.00	Z=	400.00				
RAD OF GYRATION	KROL=	70.00	KPIT=	49.96	KYAW=	49.96				
MOM OF INERTIA	ROLL=	423.	PITCH=	216.	YAW=	216.				
PROD OF INERTIA	ROL=PIT=	0.	PIT=YAW=	0.	YAW=ROL=	0.				
DG CANOPY	135.	2061.	-22.	335.	6.	9.	9.	0	2060.	2100.
DG RISER	46.	2061.	-22.	335.	6.	9.	9.	0	2060.	2100.
DG CONTR	16.	2061.	-22.	335.	6.	9.	9.	0	2060.	2100.
DG ATTACH	27.	2061.	0.	335.	6.	9.	9.	0	2060.	2100.
DG CIRC	10.	2061.	0.	335.	0.	0.	0.	0	2060.	2100.
PILOT CHUTE	24.	2084.	8.	335.	3.	5.	5.	0	2060.	2100.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

DROGUE CHUTE

W= 258.0	X=	2063.14	Y=	-16.05	Z=	335.00				
RAD OF GYRATION	KROLL=	12.24	KPIT=	10.73	KYAW=	15.27				
MOM OF INERTIA	ROLL=	8.	PITCH=	6.	YAW=	13.				
PROD OF INERTIA	ROL-PIT=	3.	PIT-YAW=	-0.	YAW-ROL=	0.				
ROTATE SYS	24.	1076.	0.	140.	10.	10.	10.	0	1050.	1100.
BEARING PLAT	59.	1076.	0.	140.	10.	10.	10.	0	1050.	1100.
TPS DELTA	4.	1076.	0.	140.	10.	10.	10.	0	1050.	1100.
BACKUP REL	99.	1076.	0.	140.	10.	10.	10.	0	1050.	1100.
ATTACH FITGS	40.	1076.	0.	140.	10.	10.	10.	0	1050.	1100.
BUSHINGS	10.	1076.	0.	140.	10.	10.	10.	0	1050.	1100.
ATTACH HDW	8.	1076.	0.	140.	10.	10.	10.	0	1050.	1100.

FWD SEP SYS

W= 244.0	X=	1076.00	Y=	0.00	Z=	140.00				
RAD OF GYRATION	KROL=	10.00	KPIT=	9.95	KYAW=	9.95				
MOM OF INERTIA	ROLL=	5.	PITCH=	5.	YAW=	5.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
AFT FTG RH	25.	2009.	119.	140.	10.	10.	10.	0	1950.	2150.
AFT FTG LH	25.	2009.	-119.	140.	10.	10.	10.	0	1950.	2150.
BOLT FTG RH	6.	2009.	119.	140.	10.	10.	10.	0	1950.	2150.
BOLT FTG LH	6.	2009.	-119.	140.	10.	10.	10.	0	1950.	2150.
EXP BOLT RH	2.	2009.	119.	140.	10.	10.	10.	0	1950.	2150.
EXP BOLT LH	2.	2009.	-119.	140.	10.	10.	10.	0	1950.	2150.
PYRO SYS RH	5.	2009.	119.	140.	10.	10.	10.	0	1950.	2150.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

PYRO SYSLH	5.	2009.	-119.	140.	10.	10.	10.	0	1950.	2150.
PYRO CIRC	10.	2009.	0.	140.	10.	10.	10.	0	1950.	2150.
DOOR TPS	15.	2009.	119.	140.	10.	10.	10.	0	1950.	2150.
DOOR TPS	15.	2009.	-119.	140.	10.	10.	10.	0	1950.	2150.
ATTACH FTG	34.	2009.	119.	140.	10.	10.	10.	0	1950.	2150.
ATTACH FTG	34.	2009.	-119.	140.	10.	10.	10.	0	1950.	2150.
ATTACH HDW	4.	2009.	119.	140.	10.	10.	10.	0	1950.	2150.
ATTACH HDW	4.	2009.	-119.	140.	10.	10.	10.	0	1950.	2150.

AFT OUTBD SE

W= 192.0	X=	2009.00	Y=	0.00	Z=	140.00
RAD OF GYRATION	KROL=	116.29	KPIT=	9.80	KYAW=	116.27
MOM OF INERTIA	ROLL=	560.	PITCH=	4.	YAW=	560.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

FITTING	179.	2009.	0.	140.	10.	10.	10.	0	1950.	2150.
SPRING	2.	2009.	0.	140.	10.	10.	10.	0	1950.	2150.
TPS DELTA	2.	2009.	0.	140.	10.	10.	10.	0	1950.	2150.
ATTACH	8.	2009.	0.	140.	10.	10.	10.	0	1950.	2150.

AFT CTR SEP

W= 191.0	X=	2009.00	Y=	0.00	Z=	140.00
RAD OF GYRATION	KROL=	10.00	KPIT=	9.87	KYAW=	9.87
MOM OF INERTIA	ROLL=	4.	PITCH=	4.	YAW=	4.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES
65K EASTERLY MISSION UNITS = INCH										
SHEAR FTGS	7.	1461.	0.	302.	3.	3.	3.	0	1456.	1466.
SHEAR FTG	7.	1110.	0.	302.	3.	3.	3.	0	1105.	1115.
ATTACH FTG	7.	1461.	95.	425.	3.	3.	3.	0	1456.	1466.
ATTACH FTG	7.	1461.	-95.	425.	3.	3.	3.	0	1456.	1466.
ATTACH FTG	7.	1110.	-95.	425.	3.	3.	3.	0	1105.	1115.
HOLD DWN	7.	1461.	95.	425.	3.	3.	3.	0	1456.	1466.
HOLD DWN	7.	1110.	-95.	425.	3.	3.	3.	0	1105.	1115.
HOLD DWNRH	7.	1461.	95.	425.	3.	3.	3.	0	1456.	1466.
SNUBBERS	29.	1620.	95.	310.	3.	11.	11.	0	1600.	1640.
SNUBBER	29.	1620.	-95.	310.	3.	11.	11.	0	1600.	1640.
PAYLOAD ATTH										
W= 114.0	X=	1477.24	Y=	0.00	Z=	351.39				
RAD OF GYRATION	KROL=	105.32	KPIT=	196.28	KYAW=	208.03				
MOM OF INERTIA	ROLL=	273.	PITCH=	948.	YAW=	1065.				
PROD OF INERTIA	ROL-PIT=	101.	PIT-YAW=	0.	YAW-ROL=	-134.				
FRAME	157.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
FTG ROT	20.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
BRACE FTG	30.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
MOTORS 2	30.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
TORQUE TUBES	25.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
TORQUE	25.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
GEAR DRIVE	30.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
STRUT	25.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
STRUT	25.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

FITTING ST	24.	1088.	0.	425.	70.	50.	50.	0	1076.	1098.
PAYLOD ROT S										
W= 391.0	X=	1088.00	Y=	0.00	Z=	425.00				
RAD OF GYRATION	KROL=	70.00	KPIT=	50.00	KYAW=	50.00				
MOM OF INERTIA	ROLL=	414.	PITCH=	211.	YAW=	211.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
TUNNEL	373.	1065.	0.	425.	10.	10.	10.	0	1050.	1100.
TUNNEL										
W= 373.0	X=	1065.00	Y=	0.00	Z=	425.00				
RAD OF GYRATION	KROL=	10.00	KPIT=	10.00	KYAW=	10.00				
MOM OF INERTIA	ROLL=	8.	PITCH=	8.	YAW=	8.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
CONT GEAR MA	331.	1712.	0.	168.	199.	49.	203.	0	1600.	1774.
CONT GEAR NG	49.	317.	0.	195.	46.	48.	50.	0	240.	390.
CONT GEAR										
W= 380.0	X=	1532.12	Y=	0.00	Z=	171.48				
RAD OF GYRATION	KROL=	186.68	KPIT=	470.16	KYAW=	504.77				
MOM OF INERTIA	ROLL=	2858.	PITCH=	18130.	YAW=	20898.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-347.				
CONT DOCK	40.	1107.	0.	400.	70.	50.	50.	0	1101.	1112.
CONT DRAG	13.	2063.	-16.	335.	12.	11.	15.	0	2060.	2100.
CONT INTSTG	176.	1562.	0.	260.	10.	12.	13.	0	1050.	2150.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
65K EASTERLY MISSION UNITS • INCH										
CONT TNL	37.	1065.	0.	425.	10.	10.	10.	0	1050.	1100.
CONT PAYLD	142.	1176.	0.	408.	70.	50.	50.	0	1076.	1640.

CONTINGENCY

W=	408.0	X=	1353.94	Y=	•0.51	Z= 342.59
RAD OF GYRATION	KROL=	87.31	KPIT=	256.56	KYAW=	245.91
MOM OF INERTIA	ROLL=	671.	PITCH=	5797.	YAW=	5325.
PROD OF INERTIA	ROL-PIT=	•32.	PIT-YAW=	0.	YAW-ROL=	•1337.

SUB-TOTAL - LANDING/DOCK

W=	10551.0	X=	1438.22	Y=	-.41	Z= 129.32
RAD OF GYRATION	KROL=	211.29	KPIT=	435.64	KYAW=	445.63
MOM OF INERTIA	ROLL=	101665.	PITCH=	432201.	YAW=	452252.
PROD OF INERTIA	ROL-PIT=	-483.	PIT-YAW=	-193.	YAW-ROL=	-35702.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

ENGINE UPR	8810.	1996.	0.	405.	38.	59.	59.	0	1940.	2125.
ENGINE LWR	8810.	2005.	0.	251.	38.	59.	59.	0	1940.	2125.
GIMBAL UPR	355.	1905.	0.	386.	38.	44.	44.	0	1865.	1940.
GIMBAL LWR	355.	1905.	0.	247.	23.	38.	38.	0	1865.	1940.
IGN&CONTRL	833.	1865.	0.	260.	60.	60.	60.	0	1800.	1940.
PROP UTILIZ	260.	1157.	0.	226.	10.	390.	390.	0	395.	1750.

ENG & ACC

W= 19422.1	X=	1979.91	Y=	0.00	Z=	323.30
RAD OF GYRATION	KROLL=	85.89	KPIT=	146.71	KYAW=	125.09
MOM OF INERTIA	ROLL=	30927.	PITCH=	90228.	YAW=	65597.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	4931.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

FILL&DRN 02	120.	1855.	110.	316.	60.	60.	5.	0	1845.	1865.
FILL&DRN H2	170.	1835.	110.	306.	60.	60.	5.	0	1825.	1845.
PRES&VENT 02	616.	1299.	-75.	358.	0.	0.	0.	0	385.	2065.
PRES&VENT H2	1242.	1500.	80.	321.	0.	0.	0.	0	900.	1975.
RECIRC 02	90.	1845.	0.	296.	40.	40.	40.	0	1750.	1865.
RECIRC H2	93.	1845.	0.	296.	40.	40.	40.	0	1750.	1865.
L&X FEED LH	1030.	1420.	-80.	331.	40.	290.	290.	0	929.	1865.
L&X FEED RH	1030.	1420.	80.	331.	40.	290.	290.	0	929.	1865.
PREVALV 02	264.	1885.	-30.	256.	9.	9.	9.	0	1870.	1900.
PREVALV 02	264.	1885.	30.	366.	9.	9.	9.	0	1870.	1900.
LH2 FEED LH	256.	1865.	-30.	286.	50.	50.	50.	0	1775.	1865.
LH2 FEED RH	256.	1835.	50.	140.	50.	50.	50.	0	1775.	1865.
PREVALV H2	167.	1810.	-60.	231.	9.	9.	9.	0	1765.	1825.
PREVALV H2	167.	1790.	50.	231.	9.	9.	9.	0	1765.	1825.
FLOW CNTL 02	219.	938.	0.	311.	60.	12.	60.	0	929.	924.
FLOW CNTL H2	223.	1765.	0.	286.	60.	20.	60.	0	1745.	1780.

PROP SYS

W=	6204.8	X=	1547.24	Y=	14.27	Z=	310.53
RAD OF GYRATION	KROLL=	90.34	KPITCH=	291.12	KYAW=	295.45	
MOM OF INERTIA	ROLL=	10931.	PITCH=	113504.	YAW=	116905.	
PROD OF INERTIA	ROL-PIT=	3636.	PIT-YAW=	-465.	YAW-ROL=	-7874.	

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

CONTINGENCY 1010. 1547. 14. 311. 0. 0. 0. 0 900. 2065.

CONTINGENCY

W= 1010.2	X=	1547.00	Y=	14.00	Z=	311.00
RAD OF GYRATION	KROL=	0.40	KPIT=	1.30	KYAW=	1.23
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - PROP-ASCENT

W= 26637.1	X=	1862.71	Y=	3.85	Z=	319.86
RAD OF GYRATION	KROL=	85.74	KPIT=	269.15	KYAW=	262.21
MOM OF INERTIA	ROLL=	42270.	PITCH=	416486.	YAW=	395302.
PROD OF INERTIA	ROL-PIT=	-3354.	PIT-YAW=	-670.	YAW-ROL=	3298.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS = INCH

FUEL SYS	338.	1579.	38.	260.	200.	140.	200.	0	1346.	1818.

PROP SYS

W= 337.5	X=	1579.00	Y=	38.00	Z=	260.00
RAD OF GYRATION	KROLL=	200.00	KPIT=	140.00	KYAW=	200.00
MOM OF INERTIA	ROLL=	2914.	PITCH=	1428.	YAW=	2914.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

TANKS&SUPT	88.	1471.	-95.	342.	16.	24.	24.	0	1418.	1526.
TANKS&SUPT	88.	1471.	95.	342.	16.	24.	24.	0	1418.	1526.

TANKAGE

W= 175.0	X=	1471.00	Y=	0.00	Z=	342.00
RAD OF GYRATION	KROL=	96.34	KPIT=	24.00	KYAW=	97.98
MOM OF INERTIA	ROLL=	351.	PITCH=	22.	YAW=	363.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.

CONTINGENCY	62.	1542.	25.	288.	0.	0.	0.	0	1434.	1766.

CONTINGENCY

W= 61.5	X=	1542.00	Y=	25.00	Z=	288.00
RAD OF GYRATION	KROL=	0.00	KPIT=	0.00	KYAW=	0.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - PROP-CRUISE

W=	574.0	X=	1542.11	Y=	25.02	Z=	288.00
RAD OF GYRATION		KROL=	167.30	KPIT=	124.07	KYAW=	170.52
MOM OF INERTIA		ROLL=	3468.	PITCH=	1907.	YAW=	3603.
PROD OF INERTIA		ROL-PIT=	102.	PIT-YAW=	-78.	YAW-ROL=	-220.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS • INCH

ENG•MNT P2	78•	365•	0•	185•	20•	9•	20•	0	362•	368•
ENG•MNT P3	116•	377•	0•	280•	9•	14•	14•	0	357•	397•
ENG•MNT T2	78•	506•	0•	318•	20•	9•	20•	0	457•	505•
ENG•MNT Y4	155•	473•	-57•	280•	9•	16•	16•	0	439•	504•
ENG•MNT Y4	155•	473•	57•	280•	9•	16•	16•	0	439•	504•
ENG•MNT Y2	78•	2020•	-100•	290•	9•	9•	9•	0	2000•	2320•
ENG•MNT Y2	78•	2020•	100•	290•	9•	9•	9•	0	2000•	2320•
ENG•MNT PR3	117•	1975•	-525•	220•	9•	14•	14•	0	1939•	2011•
ENG•MNT PR3	117•	1975•	525•	220•	9•	14•	14•	0	1939•	2011•
ENG•MNT P3	116•	1975•	0•	150•	14•	9•	14•	0	1965•	1985•
ENG•MNT T2	78•	2105•	0•	307•	40•	9•	40•	0	2095•	2125•
ENG CVR FLH	18•	473•	-57•	280•	9•	16•	16•	0	439•	504•
ENG CVR FRH	18•	473•	57•	280•	9•	16•	16•	0	439•	504•
ENG CVR AFT	38•	1975•	0•	150•	14•	9•	14•	0	1965•	1985•
CIRC•INSTL	53•	1225•	0•	251•	0•	0•	0•	0	357•	2320•

ACS THRUSTER

W•	1290•9	X•	1224•80	Y•	0•00	Z•	251•88
RAD OF GYRATION	KROL•	233•75	KPIT•	765•71	KYAW•	797•30	
MOM OF INERTIA	ROLL•	15224•	PITCH•	163364•	YAW•	177121•	
PROD OF INERTIA	ROL•PIT•	0•	PIT•YAW•	0•	YAW•ROL•	-3930•	

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
COLD HE	25.	1390.	105.	360.	0.	0.	0.	0	950.	1890.
H2 ACCUM V	10.	936.	85.	380.	17.	40.	40.	0	870.	970.
02 ACCUM V	3.	1885.	-60.	240.	10.	10.	10.	0	1865.	1910.
H2 FILL	52.	1390.	105.	360.	0.	0.	0.	0	950.	1890.
02 FILL	22.	1890.	35.	230.	55.	29.	55.	0	1865.	1880.
H2 ST FILL	159.	826.	80.	350.	12.	27.	27.	0	786.	866.
02 ST FILL	66.	1910.	-80.	210.	18.	6.	18.	0	1875.	1935.
CONN&MISC	85.	1251.	50.	317.	0.	0.	0.	0	950.	1890.
FILL-DRAIN										
W= 422.8	X=	1250.67	Y=	50.19	Z=	316.85				
RAD OF GYRATION	KROLL=	83.78	KPIT=	412.27	KYAW=	413.18				
MOM OF INERTIA	ROLL=	641.	PITCH=	15511.	YAW=	15579.				
PROD OF INERTIA	ROL-PIT=	-1653.	PIT-YAW=	289.	YAW-ROL=	-1735.				
HE TNK-SUPT	237.	956.	0.	365.	10.	10.	10.	0	936.	972.
HE VLVS-LINE	21.	1390.	105.	360.	0.	0.	0.	0	950.	1890.
H2 VLVS-LINE	112.	821.	-90.	340.	10.	40.	40.	0	791.	916.
02 VLVS-LINE	32.	1910.	70.	210.	18.	6.	18.	0	1875.	1935.
CONN&MISC	41.	1018.	-14.	345.	0.	0.	0.	0	950.	1890.
PRESS										
W= 443.8	X=	1017.77	Y=	-13.98	Z=	345.27				
RAD OF GYRATION	KROLL=	66.40	KPIT=	280.14	KYAW=	282.29				
MOM OF INERTIA	ROLL=	422.	PITCH=	7518.	YAW=	7633.				
PROD OF INERTIA	ROL-PIT=	1042.	PIT-YAW=	-48.	YAW-ROL=	-857.				

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS • INCH

02 VENT VLV	43.	1910.	70.	210.	18.	6.	18.	0	1875.	1935.
H2 VENT VLV	45.	826.	80.	350.	12.	27.	27.	0	786.	866.
02 VENT&LINE	9.	1955.	0.	540.	0.	0.	0.	0	1830.	2190.
H2 VENT&LINE	23.	721.	0.	325.	0.	0.	0.	0	510.	950.
CONN&MISC	30.	1281.	55.	308.	0.	0.	0.	0	510.	1935.

VENT SYS

W= 149.6	X=	1281.23	Y=	55.13	Z=	308.17
RAD OF GYRATION	KROLL=	86.69	KPIT=	507.65	KYAW=	502.19
MOM OF INERTIA	ROLL=	243.	PITCH=	8321.	YAW=	8143.
PROD OF INERTIA	ROL-PIT=	62.	PIT-YAW=	-32.	YAW-ROL=	-515.

H2 VALVS	244.	841.	-20.	350.	64.	40.	64.	0	786.	866.
02 VALVS	228.	1910.	0.	210.	55.	18.	55.	0	1875.	1935.
H2 LINES	131.	1225.	0.	251.	0.	0.	0.	0	357.	2320.
02 LINES	110.	1225.	0.	251.	0.	0.	0.	0	357.	2320.
CONN&MISC	179.	1313.	-7.	272.	0.	0.	0.	0	357.	2320.

ACS FEED SYS

W= 892.3	X=	1312.61	Y=	-6.88	Z=	271.83
RAD OF GYRATION	KROL=	68.82	KPIT=	396.93	KYAW=	395.26
MOM OF INERTIA	ROLL=	912.	PITCH=	30344.	YAW=	30089.
PROD OF INERTIA	ROL-PIT=	497.	PIT-YAW=	-83.	YAW-ROL=	-3669.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
02 ACCUM•MNT	265•	1885•	•60•	240•	10•	10•	10•	0	1865•	1910•
H2 ACCUM•MNT	797•	936•	85•	380•	17•	40•	40•	0	870•	970•
ACCUMULATORS										
W= 1061•5	X=	1172•82	Y=	48•81	Z=	345•06				
RAD OF GYRATION	KROL=	88•60	KPIT=	416•60	KYAW=	416•92				
MOM OF INERTIA	ROLL=	1799•	PITCH=	39765•	YAW=	39826•				
PROD OF INERTIA	ROL•PIT=	•5904•	PIT•YAW=	871•	YAW•ROL=	•5701•				
H2 CONDITION	356•	846•	•95•	350•	14•	40•	40•	0	936•	972•
02 CONDITION	336•	1800•	60•	285•	35•	22•	35•	0	1765•	1835•
COND EQUIP										
W= 692•5	X=	1309•15	Y=	•19•75	Z=	318•44				
RAD OF GYRATION	KROL=	88•05	KPIT=	479•01	KYAW=	484•52				
MOM OF INERTIA	ROLL=	1159•	PITCH=	34296•	YAW=	35089•				
PROD OF INERTIA	ROL•PIT=	5521•	PIT•YAW=	•376•	YAW•ROL=	•2315•				
02 STRT TNK	206•	1910•	60•	295•	30•	30•	30•	0	1880•	1940•
H2 STRT TNK	359•	986•	0•	365•	50•	50•	50•	0	936•	1036•
02 TANK	525•	1910•	60•	315•	60•	60•	45•	0	1870•	1960•
02 TANK	525•	1910•	•60•	315•	60•	60•	45•	0	1870•	1960•
H2 TANK	2320•	828•	0•	356•	72•	159•	159•	0	515•	1076•
TANKAGE										
W= 3934•8	X=	1187•85	Y=	3•14	Z=	342•69				
RAD OF GYRATION	KROL=	76•84	KPIT=	512•99	KYAW=	513•23				
MOM OF INERTIA	ROLL=	5015•	PITCH=	223496•	YAW=	223704•				
PROD OF INERTIA	ROL•PIT=	1925•	PIT•YAW=	•127•	YAW•ROL=	•8810•				

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES) X	Y	Z	RADII OF GYRATION (INCHES) ROLL	PITCH	YAW	DIST. DATA DI	BS (INCHES)	ES
65K EASTERLY MISSION UNITS = INCH										
ACPS CONT	1069.	1227.	11.	300.	0.	0.	0.	0	357.	2320.
CONTINGENCY										
W= 1068.9	X=	1227.00	Y=	11.00	Z=	300.00				
RAD OF GYRATION	KROL=	0.42	KPIT=	1.07	KYAW=	0.98				
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.				
PROD OF INERTIA	ROL*PIT=	0.	PIT*YAW=	0.	YAW*ROL=	0.				
RL10 & MNT	332.	2070.	81.	335.	10.	20.	20.	0	2045.	2125.
RL10 & MNT	332.	2070.	-81.	335.	10.	20.	20.	0	2045.	2125.
CIRC-INSTL	3.	2070.	0.	335.	0.	0.	0.	0	2000.	2045.
OMS THRUSTER										
W= 667.0	X=	2070.00	Y=	0.00	Z=	335.00				
RAD OF GYRATION	KROL=	81.43	KPIT=	19.94	KYAW=	83.24				
MOM OF INERTIA	ROLL=	955.	PITCH=	57.	YAW=	998.				
PROD OF INERTIA	ROL*PIT=	0.	PIT*YAW=	0.	YAW*ROL=	-0.				
H2 VALVS	124.	841.	-20.	350.	64.	40.	64.	0	786.	866.
O2 VALVS	73.	1910.	0.	210.	55.	18.	55.	0	1875.	1935.
H2 LINES	429.	1485.	0.	350.	60.	300.	300.	0	1015.	2085.
O2 LINES	103.	1985.	0.	345.	60.	84.	84.	0	1850.	2085.
JNTS & COUP	238.	1488.	-3.	335.	0.	0.	0.	0	786.	2085.
SUPT & MISC	145.	1488.	-3.	335.	0.	0.	0.	0	786.	2085.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

OMS FEED SYS

W= 1111.9	X= 1488.49	Y= -3.26	Z= 335.20
RAD OF GYRATION	KROL= 59.65	KPIT= 343.51	KYAW= 342.56
MOM OF INERTIA	ROLL= 854.	PITCH= 28319.	YAW= 28162.
PROD OF INERTIA	ROL-PIT= 347.	PIT-YAW= -8.	YAW-ROL= -982.

OMS CONT 141. 1706. -2. 335. 0. 0. 0. 0 357. 2320.

CONTINGENCY

W= 141.0	X= 1706.00	Y= -2.00	Z= 335.00
RAD OF GYRATION	KROL= 0.00	KPIT= 0.00	KYAW= 0.00
MOM OF INERTIA	ROLL= 0.	PITCH= 0.	YAW= 0.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

SUB-TOTAL - PROP-AUXIL

W= 11877.0	X= 1291.39	Y= 6.35	Z= 319.97
RAD OF GYRATION	KROL= 109.42	KPIT= 514.04	KYAW= 519.20
MOM OF INERTIA	ROLL= 30694.	PITCH= 677368.	YAW= 691043.
PROD OF INERTIA	ROL-PIT= -27.	PIT-YAW= 763.	YAW-ROL= -27887.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS - INCH

APU #1	231.	1797.	-22.	283.	10.	22.	22.	0	1765.	1835.
APU #2	231.	1797.	-52.	283.	10.	22.	22.	0	1765.	1835.
APU #3	231.	1797.	-82.	283.	10.	22.	22.	0	1765.	1835.
APU #4	231.	1797.	-112.	283.	10.	22.	22.	0	1765.	1835.

APU TOTAL

W= 925.0	X=	1797.00	Y=	-67.00	Z=	283.00
RAD OF GYRATION	KROL=	35.00	KPIT=	22.05	KYAW=	40.14
MOM OF INERTIA	ROLL=	245.	PITCH=	97.	YAW=	322.
PROD OF INERTIA	ROL-PIT=	-0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
FUEL CELL #1	263.	346.	-11.	234.	9.	9.	5.	0	338.	356.
FUEL CELL #2	263.	308.	-18.	237.	9.	5.	9.	0	300.	318.
FUEL CELL #3	263.	346.	11.	234.	9.	9.	5.	0	338.	356.
FUEL CELL #4	263.	308.	18.	237.	9.	5.	9.	0	300.	318.
FUELCELLS										
W= 1051.0	X=	327.00	Y=	0.00	Z=	235.50				
RAD OF GYRATION	KROLL=	17.49	KPIT=	20.41	KYAW=	25.23				
MOM OF INERTIA	ROLL=	69.	PITCH=	94.	YAW=	144.				
PROD OF INERTIA	ROL-PIT=	-0.	PIT-YAW=	0.	YAW-ROL=	-6.				
CONTING-APU	138.	1797.	-67.	283.	30.	22.	30.	0	1765.	1835.
CONTING-FC	158.	327.	0.	236.	12.	12.	12.	0	300.	356.
CONTINGENCY										
W= 296.0	X=	1012.34	Y=	-31.24	Z=	257.91				
RAD OF GYRATION	KROLL=	46.51	KPIT=	733.90	KYAW=	734.42				
MOM OF INERTIA	ROLL=	138.	PITCH=	34411.	YAW=	34460.				
PROD OF INERTIA	ROL-PIT=	-1566.	PIT-YAW=	-50.	YAW-ROL=	1098.				

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - PRIME POWER

W=	2272.0	X=	1014.77	Y=	-31.35	Z=	257.76
RAD OF GYRATION	KROL=		48.81	KPIT=	734.16	KYAW=	734.93
MOM OF INERTIA	ROLL=		1168.	PITCH=	264313.	YAW=	264873.
PROD OF INERTIA	ROL-PIT=		-12024.	PIT-YAW=	-388.	YAW-ROL=	8507.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES
65K EASTERLY MISSION UNITS = INCH										
ALTERNATOR=1	28.	1797.	-22.	283.	4.	3.	3.	0	1765.	1835.
ALTERNATOR=2	28.	1797.	-52.	283.	4.	3.	3.	0	1765.	1835.
ALTERNATOR=3	28.	1797.	-82.	283.	4.	3.	3.	0	1765.	1835.
ALTERNATORS										
W= 84.0	X=	1797.00	Y=	-52.00	Z=	283.00				
RAD OF GYRATION	KROL=	24.82	KPIT=	3.00	KYAW=	24.68				
MOM OF INERTIA	ROLL=	11.	PITCH=	0.	YAW=	11.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
P DIST UNIT	110.	343.	-43.	219.	6.	6.	6.	0	335.	353.
P DIST UNIT	110.	343.	43.	219.	6.	6.	6.	0	335.	353.
P CNTL UNIT	40.	321.	-35.	209.	12.	6.	6.	0	318.	324.
P CNTL UNIT	40.	321.	35.	209.	12.	6.	6.	0	318.	324.
AC CONTL	60.	1797.	-52.	283.	8.	6.	6.	0	1765.	1835.
PWR CNTRL										
W= 360.0	X=	580.44	Y=	-8.67	Z=	227.44				
RAD OF GYRATION	KROL=	49.76	KPIT=	544.75	KYAW=	545.80				
MOM OF INERTIA	ROLL=	192.	PITCH=	23058.	YAW=	23147.				
PROD OF INERTIA	ROL-PIT=	-819.	PIT-YAW=	-37.	YAW-ROL=	1053.				
LDG LIGHT N	8.	340.	0.	190.	3.	3.	3.	0	240.	395.
LDG LIGHT M	8.	1683.	-200.	180.	3.	3.	3.	0	1650.	1785.
LDG LIGHT M	8.	1683.	200.	180.	3.	3.	3.	0	1650.	1785.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

UTILITY SYS

W= 24.0	X=	1235.33	Y=	0.00	Z=	183.33				
RAD OF GYRATION	KROLL=	163.39	KPIT=	633.12	KYAW=	653.82				
MOM OF INERTIA	ROLL=	138.	PITCH=	2076.	YAW=	2214.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-15.				
MOUNTS	20.	811.	-17.	238.	0.	0.	0.	0	318.	1835.

SUPT & INSTL

W= 20.0	X=	811.00	Y=	-17.00	Z=	238.00				
RAD OF GYRATION	KROL=	0.00	KPIT=	0.00	KYAW=	0.00				
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
CIRCUITRY	645.	832.	-16.	235.	0.	0.	0.	0	318.	1835.

DIST CIRC

W= 645.0	X=	832.00	Y=	-16.00	Z=	235.00				
RAD OF GYRATION	KROL=	0.00	KPIT=	0.00	KYAW=	0.00				
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
CONTINGENCY	170.	832.	-16.	235.	0.	0.	0.	0	318.	1835.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

CONTINGENCY

W= 170.0	X=	832.00	Y=	-16.00	Z=	235.00
RAD OF GYRATION	KROL=	0.00	KPIT=	0.00	KYAW=	0.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - ELEC DIST

W= 1303.0	X=	831.82	Y=	-16.02	Z=	235.10
RAD OF GYRATION	KROL=	39.14	KPIT=	412.44	KYAW=	413.33
MOM OF INERTIA	ROLL=	431.	PITCH=	47840.	YAW=	48047.
PROD OF INERTIA	ROL-PIT=	-1559.	PIT-YAW=	-77.	YAW-ROL=	1917.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS • INCH

MAIN PUMP•1	80•	1797•	•22•	283•	6•	6•	6•	0	1773•	1842•
MAIN PUMP•2	80•	1797•	•52•	283•	6•	6•	6•	0	1773•	1842•
MAIN PUMP•3	80•	1797•	•82•	283•	6•	6•	6•	0	1773•	1842•
MAIN PUMP•4	80•	1797•	•112•	283•	6•	6•	6•	0	1773•	1842•
RESERV8IR•1	58•	1797•	•22•	283•	6•	6•	6•	0	1773•	1842•
RESERV8IR•2	58•	1797•	•52•	283•	6•	6•	6•	0	1773•	1842•
RESERV8IR•3	58•	1797•	•82•	283•	6•	6•	6•	0	1773•	1842•
RESERV8IR•4	59•	1797•	•112•	283•	6•	6•	6•	0	1773•	1842•

P8WER SUPPLY

W•	553•0	X•	1797•00	Y•	•67•08	Z•	283•00
RAD 8F GYRATI8N	KR8L•	34•10	KPIT•	5•80	KYAW•	34•06	
M8M 8F INERTIA	R8LL•	139•	PITCH•	4•	YAW•	138•	
PR8D 8F INERTIA	R8L•PIT•	0•	PIT•YAW•	•0•	YAW•R8L•	0•	

MANIFLD ETC1	68•	1797•	•22•	283•	5•	5•	5•	0	1773•	1842•
MANIFLD ETC2	68•	1797•	•52•	283•	5•	5•	5•	0	1773•	1842•
MANIFLD ETC3	67•	1797•	•82•	283•	5•	5•	5•	0	1773•	1842•

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
MANIFLD ETC4	67.	1797.	-112.	283.	5.	5.	5.	0	1773.	1842.
ELEV MANFLD	14.	1905.	0.	250.	1.	1.	1.	0	1855.	1955.
ABES VCP LBB	35.	1745.	-350.	150.	2.	2.	2.	0	1705.	1797.
ABES VCP RBB	35.	1745.	350.	150.	2.	2.	2.	0	1705.	1797.
ABES VCP LIB	35.	1515.	-125.	150.	2.	2.	2.	0	1475.	1797.
ABES VCP RIB	35.	1515.	125.	150.	2.	2.	2.	0	1475.	1797.
MG VCP RH	76.	1605.	190.	180.	2.	2.	2.	0	1600.	1797.
MG VCP LH	76.	1605.	-190.	180.	2.	2.	2.	0	1600.	1797.
NG VLV CR PL	73.	395.	0.	190.	2.	2.	2.	0	390.	1797.
ACPS DR VCP	11.	2065.	0.	140.	1.	1.	1.	0	2060.	2070.
ACPS DR VCP	11.	370.	30.	175.	1.	1.	1.	0	365.	375.
ACPS DR VCP	11.	370.	-30.	175.	1.	1.	1.	0	365.	375.
CARGB DR VCP	10.	1850.	95.	420.	1.	1.	1.	0	1797.	1855.
CARGB DR VCP	10.	1105.	95.	420.	1.	1.	1.	0	1100.	1797.
DIST CNTL CT										
W= 702.0	X=	1528.86	Y=	-22.98	Z=	222.12				
RAD OF GYRATION	KROL=	166.63	KPIT=	474.33	KYAW=	494.19				
MOM OF INERTIA	ROLL=	4207.	PITCH=	34091.	YAW=	37005.				
PROD OF INERTIA	ROL-PIT=	-1065.	PIT-YAW=	-156.	YAW-ROL=	1342.				
HX ETC-1	71.	1797.	-22.	283.	5.	5.	5.	0	1773.	1842.
HX ETC-2	71.	1797.	-52.	283.	5.	5.	5.	0	1773.	1842.
HX ETC-3	71.	1797.	-82.	283.	5.	5.	5.	0	1773.	1842.
HX ETC-4	72.	1797.	-112.	283.	5.	5.	5.	0	1773.	1842.

65K EASTERLY MISSION UNITS • INCH

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

TEMP CNTL

W=	285.0	X=	1797.00	Y=	-67.16	Z=	283.00			
RAD OF GYRATION		KROLL=	33.96	KPIT=	4.90	KYAW=	33.94			
MOM OF INERTIA		ROLL=	71.	PITCH=	1.	YAW=	71.			
PROD OF INERTIA		ROL-PIT=	-0.	PIT-YAW=	-0.	YAW-ROL=	0.			

ELEC PUMP-1	22.	1797.	-22.	283.	4.	4.	4.	0	1773.	1842.
ELEC PUMP-2	22.	1797.	-52.	283.	4.	4.	4.	0	1773.	1842.
ELEC PUMP-3	22.	1797.	-82.	283.	4.	4.	4.	0	1773.	1842.
ELEC PUMP-4	22.	1797.	-112.	283.	4.	4.	4.	0	1773.	1842.

AUX SYSTEM

W=	88.0	X=	1797.00	Y=	-67.00	Z=	283.00			
RAD OF GYRATION		KROLL=	33.78	KPIT=	4.00	KYAW=	33.78			
MOM OF INERTIA		ROLL=	22.	PITCH=	0.	YAW=	22.			
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-0.			

BAY STRUCT	418.	1797.	-67.	283.	35.	22.	39.	0	1773.	1842.

SUPTS INSTL

W=	418.0	X=	1797.00	Y=	-67.00	Z=	283.00			
RAD OF GYRATION		KROLL=	35.00	KPIT=	22.00	KYAW=	39.00			
MOM OF INERTIA		ROLL=	111.	PITCH=	44.	YAW=	137.			
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.			

CONTINGENCY	714.	1705.	-52.	262.	0.	0.	0.	0	390.	1955.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

CONTINGENCY

W= 714.0	X=	1705.00	Y=	-52.00	Z=	262.00
RAD OF GYRATION	KROL=	0.00	KPIT=	0.00	KYAW=	0.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - HYDRA DIST

W= 2760.0	X=	1705.00	Y=	-51.96	Z=	262.08
RAD OF GYRATION	KROL=	92.63	KPIT=	264.46	KYAW=	273.99
MOM OF INERTIA	ROLL=	5112.	PITCH=	41664.	YAW=	44722.
PROD OF INERTIA	ROL-PIT=	-2241.	PIT-YAW=	-423.	YAW-ROL=	2967.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

ELEV ACT LID	344.	1960.	-230.	190.	3.	19.	19.	0	1930.	1990.
ELEV ACT LMD	344.	1960.	-330.	200.	3.	19.	19.	0	1930.	1990.
ELEV ACT LOD	345.	1960.	-420.	220.	3.	19.	19.	0	1930.	1990.
ELEV ACT RID	344.	1960.	230.	190.	3.	19.	19.	0	1930.	1990.
ELEV ACT RMD	344.	1960.	330.	200.	3.	19.	19.	0	1930.	1990.
ELEV ACT ROD	345.	1960.	420.	220.	3.	19.	19.	0	1930.	1990.

ELEV ACT

W= 2066.0	X=	1960.00	Y=	0.00	Z=		203.35
RAD OF GYRATION	KROL=	336.09	KPIT=	22.69	KYAW=		336.38
MOM OF INERTIA	ROLL=	50372.	PITCH=	230.	YAW=		50458.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		-0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS • INCH

EL SNDRY LH	26.	1920.	-330.	200.	5.	1.	5.	0	1915.	1925.
EL SNDRY RH	26.	1920.	330.	200.	5.	1.	5.	0	1915.	1925.

ELEV SEC ACT

W= 52.0	X=	1920.00	Y=	0.00	Z=		200.00
RAD OF GYRATION	KROL=	330.04	KPIT=	1.00	KYAW=		330.04
MOM OF INERTIA	ROLL=	1223.	PITCH=	0.	YAW=		1223.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		0.

ELEV SUPT LH	114.	1930.	-330.	200.	60.	1.	60.	0	1925.	1935.
ELEV SUPT RH	114.	1930.	330.	200.	60.	1.	60.	0	1925.	1935.

ELEV SUPTS

W= 228.0	X=	1930.00	Y=	0.00	Z=		200.00
RAD OF GYRATION	KROL=	335.41	KPIT=	0.35	KYAW=		335.41
MOM OF INERTIA	ROLL=	5536.	PITCH=	-0.	YAW=		5536.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		0.

PLUMBING LH	49.	1930.	-240.	180.	60.	0.	60.	0	1910.	1980.
PLUMBING RH	49.	1930.	240.	180.	60.	0.	60.	0	1910.	1980.

ELEV PWR TRN

W= 98.0	X=	1930.00	Y=	0.00	Z=		180.00
RAD OF GYRATION	KROL=	247.39	KPIT=	0.00	KYAW=		247.39
MOM OF INERTIA	ROLL=	1295.	PITCH=	0.	YAW=		1295.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		-0.

CIRCUITRY LH	18.	1890.	-215.	260.	0.	0.	0.	0	1835.	1960.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

CIRCUITRY RH	18.	1890.	215.	260.	0.	0.	0.	0	1835.	1960.
LINKAGE LH	51.	1920.	-330.	200.	60.	1.	60.	0	1915.	1935.
LINKAGE RH	51.	1920.	330.	200.	60.	1.	60.	0	1915.	1935.

ELEV CNTLS

W= 138.0	X=	1912.17	Y=	0.00	Z=	215.65
RAD OF GYRATION	KROLL=	309.69	KPIT=	29.48	KYAW=	308.84
MOM OF INERTIA	ROLL=	2857.	PITCH=	26.	YAW=	2841.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-10.

RUD ACT UPR	232.	2135.	0.	730.	4.	9.	5.	0	2120.	2150.
RUD ACT LWR	233.	2095.	0.	660.	4.	9.	5.	0	2080.	2110.

RUDDER ACT

W= 465.0	X=	2114.96	Y=	0.00	Z=	694.92
RAD OF GYRATION	KROL=	35.23	KPIT=	41.32	KYAW=	20.63
MOM OF INERTIA	ROLL=	125.	PITCH=	171.	YAW=	43.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	70.

RUD SEC ACT	26.	2085.	0.	710.	2.	5.	2.	0	2080.	2090.

RUD SEC ACT

W= 26.0	X=	2085.00	Y=	0.00	Z=	710.00
RAD OF GYRATION	KROL=	2.00	KPIT=	5.00	KYAW=	2.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

RUD SUPTS	67.	2085.	0.	710.	2.	5.	2.	0	2080.	2090.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS • INCH

RUD SUPTS

W= 67.0	X= 2085.00	Y= 0.00	Z= 710.00
RAD OF GYRATION	KROLL= 2.00	KPIT= 5.00	KYAW= 2.00
MOM OF INERTIA	ROLL= 0.	PITCH= 0.	YAW= 0.
PROD OF INERTIA	ROL•PIT= 0.	PIT•YAW= 0.	YAW•ROL= 0.

RUD PLUMBING	48.	1965.	0.	500.	0.	0.	0.	0	1800.	2140.

RUD PWR TRN

W= 48.0	X= 1965.00	Y= 0.00	Z= 500.00
RAD OF GYRATION	KROLL= 0.00	KPIT= 0.00	KYAW= 0.00
MOM OF INERTIA	ROLL= 0.	PITCH= 0.	YAW= 0.
PROD OF INERTIA	ROL•PIT= 0.	PIT•YAW= 0.	YAW•ROL= 0.

RUD CIRC	18.	1965.	0.	500.	0.	0.	0.	0	1800.	2140.
RUD LINKAGE	39.	2085.	0.	710.	2.	5.	2.	0	2080.	2090.

RUD CONTROLS

W= 57.0	X= 2047.11	Y= 0.00	Z= 643.68
RAD OF GYRATION	KROLL= 97.63	KPIT= 112.51	KYAW= 55.81
MOM OF INERTIA	ROLL= 117.	PITCH= 156.	YAW= 38.
PROD OF INERTIA	ROL•PIT= 0.	PIT•YAW= 0.	YAW•ROL= 67.

SPBR LH UPR	228.	1845.	-120.	350.	1.	9.	9.	0	1830.	1860.
SPBR LH LWR	228.	1845.	-120.	310.	1.	9.	9.	0	1830.	1860.
SPBR RH UPR	228.	1845.	120.	350.	1.	9.	9.	0	1830.	1860.
SPBR RH LWR	228.	1845.	120.	310.	1.	9.	9.	0	1830.	1860.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

SPBR ACT

W= 912.0	X= 1845.00	Y= 0.00	Z= 330.00
RAD OF GYRATION	KROL= 121.66	KPIT= 21.91	KYAW= 120.33
MOM OF INERTIA	ROLL= 2914.	PITCH= 95.	YAW= 2850.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -0.

SPBR SC LH	26.	1820.	-120.	330.	4.	4.	1.	0	1815.	1825.
SPBR SC RH	26.	1820.	120.	330.	4.	4.	1.	0	1815.	1825.

SP BR SC ACT

W= 52.0	X= 1820.00	Y= 0.00	Z= 330.00
RAD OF GYRATION	KROL= 120.07	KPIT= 4.00	KYAW= 120.00
MOM OF INERTIA	ROLL= 162.	PITCH= 0.	YAW= 162.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

SPBR PL LH	4.	1815.	-70.	310.	0.	0.	0.	0	1800.	1865.
SPBR PL RH	4.	1815.	70.	310.	0.	0.	0.	0	1800.	1865.

SP BR PWR TR

W= 8.0	X= 1815.00	Y= -0.00	Z= 310.00
RAD OF GYRATION	KROL= 70.00	KPIT= 0.00	KYAW= 70.00
MOM OF INERTIA	ROLL= 8.	PITCH= 0.	YAW= 8.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

SPBR CIRC LH	4.	1815.	-70.	310.	0.	0.	0.	0	1800.	1865.
SPBR CIRC RH	4.	1815.	70.	310.	0.	0.	0.	0	1800.	1865.
SPBR LINK LH	32.	1820.	-120.	330.	4.	4.	1.	0	1815.	1825.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

SPBR LINK RH	32.	1820.	120.	330.	4.	4.	1.	0	1815.	1825.
TVC LINK	10.	1920.	0.	320.	5.	5.	5.	0	1865.	1954.

SP BR CNTLS

W= 82.0	X=	1831.71	Y=	0.00	Z=		326.83
RAD OF GYRATION	KROLL=	108.51	KPIT=	33.81	KYAW=		113.17
MOM OF INERTIA	ROLL=	208.	PITCH=	20.	YAW=		227.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		-1.

SPBR SP LH	65.	1820.	-120.	330.	4.	4.	1.	0	1815.	1825.
SPBR SP RH	65.	1820.	120.	330.	4.	4.	1.	0	1815.	1825.
TVC SUPT SEC	14.	1920.	0.	320.	5.	5.	5.	0	1865.	1954.

SP BR SUPTS

W= 144.0	X=	1829.72	Y=	0.00	Z=		329.03
RAD OF GYRATION	KROLL=	114.13	KPIT=	30.07	KYAW=		117.82
MOM OF INERTIA	ROLL=	405.	PITCH=	28.	YAW=		431.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		-3.

CONTINGENCY	458.	1944.	0.	308.	0.	0.	0.	0	1800.	2150.

CONTINGENCY

W= 458.0	X=	1944.00	Y=	0.00	Z=		308.00
RAD OF GYRATION	KROLL=	0.00	KPIT=	0.00	KYAW=		0.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=		0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - SURF CONTROL

W=	4901.0	X=	1943.78	Y=	.00	Z= 307.94
RAD OF GYRATION		KROL=	294.21	KPIT=	177.85	KYAW= 259.98
MOM OF INERTIA		ROLL=	91568.	PITCH=	33461.	YAW= 71500.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL= 7277.

65K EASTERLY MISSION UNITS - INCH

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
AV BAY FLH	744.	1028.	-87.	376.	19.	27.	25.	0	989.	1067.
AV BAY FRH	755.	1028.	87.	376.	19.	27.	25.	0	989.	1067.
AV BAY NLGL	43.	302.	-26.	233.	4.	27.	30.	0	258.	352.
AV BAY NLGR	43.	302.	26.	233.	4.	27.	30.	0	258.	352.
NAV BASE	853.	849.	0.	435.	42.	19.	42.	0	829.	867.
AV BAY ALH	214.	1845.	-104.	348.	17.	20.	12.	0	1825.	1865.
AV BAY ARH	214.	1845.	104.	348.	17.	20.	12.	0	1825.	1865.
AV BAY MLGL	70.	1660.	170.	160.	8.	10.	10.	0	1650.	1785.
AV BAY MLGR	35.	1660.	-170.	160.	8.	10.	10.	0	1650.	1785.

AVIONICS EQ

W= 2971.0	X=	1095.81	Y=	2.36	Z=	377.09
RAD OF GYRATION	KROL=	102.52	KPIT=	366.19	KYAW=	370.77
MOM OF INERTIA	ROLL=	6740.	PITCH=	85988.	YAW=	88153.
PROD OF INERTIA	ROL-PIT=	714.	PIT-YAW=	-281.	YAW-ROL=	-5293.

S-BAND ANT	13.	800.	0.	428.	26.	15.	26.	0	604.	880.
UHF ANT	72.	796.	0.	145.	26.	15.	26.	0	700.	950.
DME ANT UPR	32.	686.	0.	390.	26.	15.	26.	0	604.	880.
DME ANT LWR	32.	930.	0.	145.	26.	15.	26.	0	700.	950.
G.S. ANT	46.	738.	0.	145.	26.	15.	26.	0	700.	950.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES (INCHES)
65K EASTERLY MISSION UNITS • INCH										
V8R/L8C ANT	123•	1062•	0•	288•	84•	33•	90•	0	1004•	1116•
RDR ALT ANT	90•	800•	0•	145•	26•	15•	26•	0	700•	950•
ANTENNAS										
W= 407•5	X=	872•76	Y=	0•00	Z=	216•29				
RAD 8F GYRATI8N	KR8L=	104•52	KPIT=	164•34	KYAW=	145•32				
M8M 8F INERTIA	R8LL=	961•	PITCH=	2375•	YAW=	1858•				
PR8D 8F INERTIA	R8L=PIT=	0•	PIT=YAW=	0•	YAW=R8L=	348•				
D8CK STA	34•	1002•	0•	479•	5•	5•	5•	0	994•	1009•
D8CK STA										
W= 34•4	X=	1002•00	Y=	0•00	Z=	479•00				
RAD 8F GYRATI8N	KR8L=	5•02	KPIT=	5•07	KYAW=	5•05				
M8M 8F INERTIA	R8LL=	0•	PITCH=	0•	YAW=	0•				
PR8D 8F INERTIA	R8L=PIT=	0•	PIT=YAW=	0•	YAW=R8L=	0•				
CTR PANEL	190•	903•	0•	464•	8•	6•	6•	0	900•	911•
CMD PLT PNL	231•	903•	-21•	464•	8•	6•	6•	0	900•	911•
PIL8T PNL	230•	903•	21•	464•	8•	6•	6•	0	900•	911•
LH C8NS8LE	49•	932•	-41•	442•	8•	9•	8•	0	924•	945•
RH C8NSL8E	37•	932•	41•	442•	8•	9•	8•	0	924•	945•
CTR C8NS8LE	252•	932•	0•	442•	8•	9•	8•	0	924•	945•
8VHD PNLS	52•	926•	0•	492•	15•	10•	15•	0	920•	930•
LH PED/STK	52•	911•	-21•	454•	7•	9•	7•	0	903•	920•
RHPED/STK	52•	911•	21•	454•	7•	9•	7•	0	903•	920•

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS • INCH

DISP&CNTRL

W= 1144.8	X=	913.33	Y=	-0.46	Z=	457.89	
RAD OF GYRATION	KROL=	23.74	KPIT=	19.43	KYAW=	23.64	
MOM OF INERTIA	ROLL=	139.	PITCH=	93.	YAW=	140.	
PROD OF INERTIA	ROL-PIT=	-2.	PIT-YAW=	2.	YAW-ROL=	-26.	

DATA BUS	30.	1110.	0.	363.	0.	0.	0.	0	356.	1865.

DATA BUS

W= 30.3	X=	1110.00	Y=	0.00	Z=	363.00	
RAD OF GYRATION	KROL=	0.41	KPIT=	1.11	KYAW=	1.03	
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.	
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.	

SUB-TOTAL - AVIONICS

W= 4588.0	X=	1029.86	Y=	1.41	Z=	383.64	
RAD OF GYRATION	KROL=	109.00	KPIT=	318.95	KYAW=	315.41	
MOM OF INERTIA	ROLL=	11766.	PITCH=	100742.	YAW=	98514.	
PROD OF INERTIA	ROL-PIT=	825.	PIT-YAW=	-297.	YAW-ROL=	-5103.	

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES (INCHES)
65K EASTERLY MISSION UNITS - INCH										
Ø2 SCNDRY	21.	885.	78.	400.	6.	6.	6.	0	874.	896.
DIL N2 FWD	50.	891.	78.	375.	6.	6.	6.	0	880.	902.
DIL N2 AFT	50.	933.	78.	375.	6.	6.	6.	0	922.	944.
Ø2 DEL EQUIP	10.	950.	65.	400.	35.	35.	35.	0	920.	980.
N2 DEL EQUIP	8.	950.	65.	400.	35.	35.	35.	0	920.	980.
MNTG SUPP Ø2	8.	885.	78.	390.	5.	5.	6.	0	875.	895.
MNTG SUPP N2	19.	911.	78.	383.	5.	5.	6.	0	900.	922.
ATMØS GAS										
W= 166.0	X=	911.29	Y=	76.59	Z=	382.51				
RAD ØF GYRATIØN	KRØL=	16.97	KPIT=	28.65	KYAW=	27.03				
MØM ØF INERTIA	RØLL=	10.	PITCH=	29.	YAW=	26.				
PRØD ØF INERTIA	RØL-PIT=	-2.	PIT-YAW=	-1.	YAW-RØL=	0.				
C GAS CNT S	99.	936.	47.	448.	6.	6.	8.	0	929.	949.
LIØH CART	70.	950.	-47.	417.	4.	4.	4.	0	940.	960.
CANNISTERS	51.	928.	-47.	417.	4.	4.	4.	0	918.	938.
FANS	76.	974.	-47.	417.	4.	4.	4.	0	962.	986.
CØND HX	31.	953.	-47.	408.	3.	3.	3.	0	948.	958.
WIND DFØG HX	53.	892.	-47.	417.	4.	4.	4.	0	885.	899.
HX	50.	992.	47.	417.	8.	8.	8.	0	982.	1002.
CØNTRØLS	10.	908.	-47.	430.	9.	9.	14.	0	897.	923.
DUCT LEFT	101.	945.	-60.	468.	12.	12.	12.	0	925.	965.
DUCT RIGHT	101.	945.	60.	468.	12.	12.	12.	0	925.	965.
MNTG SUPP	42.	948.	-47.	417.	5.	5.	5.	0	925.	965.

65K EASTERLY UNITS - INCH

GAS MNGT

W=	635.0	X=	945.50	Y=	-12.62	Z=	436.39			
RAD OF GYRATION		KROLL=	55.35	KPIT=	33.64	KYAW=	55.31			
MOM OF INERTIA		ROLL=	453.	PITCH=	167.	YAW=	452.			
PROD OF INERTIA		ROL-PIT=	27.	PIT-YAW=	69.	YAW-ROL=	-9.			

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES) X	Y	Z	RADII OF GYRATION (INCHES) ROLL	PITCH	YAW	DIST. DATA DI	BS (INCHES)	ES
CAB CIRC CP	41.	913.	0.	457.	3.	8.	8.	0	903.	923.
CAB CIRC PLU	6.	969.	-38.	360.	3.	8.	8.	0	959.	979.
CAB CIRC RES	5.	969.	-38.	360.	8.	3.	8.	0	959.	979.
CAB CIRC PUM	30.	969.	-38.	360.	8.	8.	8.	0	959.	979.
COND H2O SYS	13.	969.	-38.	360.	3.	8.	8.	0	959.	979.
INFACE HX	93.	913.	0.	457.	8.	3.	8.	0	903.	923.
E CIRC CP FL	51.	946.	-30.	385.	8.	8.	8.	0	926.	966.
E CIRC CP FR	51.	946.	30.	385.	3.	8.	8.	0	926.	966.
E CIRC CP AL	10.	1345.	-105.	345.	8.	8.	8.	0	1825.	1365.
E CIRC CP AR	10.	1345.	105.	345.	3.	8.	8.	0	1825.	1365.
E CIRC CP NO	6.	291.	0.	226.	8.	8.	8.	0	271.	311.
CP MLG LEFT	5.	1695.	-200.	183.	8.	3.	8.	0	1675.	1715.
CP MLG RIGHT	5.	1695.	200.	183.	3.	8.	8.	0	1675.	1715.
TEMP CNT PAN	98.	913.	0.	457.	6.	6.	6.	0	903.	923.
E CIRC PLUMB	65.	1030.	53.	417.	6.	6.	6.	0	1020.	1040.
E CIRC PUMP	59.	1030.	53.	417.	6.	6.	6.	0	1020.	1040.
E CIRC RESER	24.	1041.	53.	417.	4.	4.	4.	0	1021.	1051.
PANELS	757.	1510.	0.	490.	58.	149.	160.	0	1076.	1591.
CNTR/MECH	440.	1076.	0.	490.	58.	6.	58.	0	1076.	1096.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
65K EASTERLY				UNITS - INCH						
GR CØØL HX	9.	1018.	53.	417.	4.	4.	4.	0	1013.	1023.
H2 BØILER HX	96.	1116.	100.	330.	4.	9.	9.	0	1110.	1130.
VALV CNTR	55.	969.	-88.	360.	4.	4.	4.	0	955.	975.
MNTG SUPP	79.	1030.	53.	417.	4.	4.	4.	0	1010.	1050.
HEAT TRANS										
W= 2009.0	X=	1137.93	Y=	6.23	Z=	453.87				
RAD ØF GYRATIØN	KRØL=	82.59	KPIT=	206.86	KYAW=	208.87				
MØM ØF INERTIA	RØLL=	2958.	PITCH=	18556.	YAW=	18917.				
PRØD ØF INERTIA	RØL-PIT=	15.	PIT-YAW=	-162.	YAW-RØL=	1306.				
TANKAGE	77.	330.	0.	235.	5.	5.	5.	0	320.	340.
PLUMB/CNTR	37.	330.	0.	235.	5.	5.	5.	0	320.	340.
MNTG SUPP	22.	330.	0.	235.	5.	5.	5.	0	320.	340.
WSTE MNGT SY	192.	999.	-68.	408.	20.	14.	20.	0	969.	1029.
MNTG SUPP	17.	999.	-68.	408.	20.	14.	20.	0	969.	1029.
WATER MNGT										
W= 345.0	X=	735.28	Y=	-41.19	Z=	339.80				
RAD ØF GYRATIØN	KRØL=	92.22	KPIT=	337.87	KYAW=	323.99				
MØM ØF INERTIA	RØLL=	633.	PITCH=	8501.	YAW=	8060.				
PRØD ØF INERTIA	RØL-PIT=	-809.	PIT-YAW=	-209.	YAW-RØL=	2058.				
PURGE LINER	677.	1076.	0.	226.	84.	405.	405.	0	370.	1800.
SUPLY UP LE	107.	1076.	-125.	285.	8.	405.	405.	0	370.	1800.
SUPLY DØ LE	106.	1076.	-130.	165.	7.	405.	405.	0	370.	1800.
SUPLY UP RI	107.	1076.	125.	285.	7.	405.	405.	0	370.	1800.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES (INCHES)
65K EASTERLY				UNITS - INCH						
SUPLY DU RI	106.	1076.	130.	165.	8.	405.	405.	0	370.	1800.
FIRE EXTING	16.	949.	0.	430.	3.	3.	3.	0	945.	953.
PURGE SYS										
W= 1119.0	X=	1074.18	Y=	.00	Z=	228.64				
RAD OF GYRATION	KROL=	111.53	KPIT=	404.80	KYAW=	410.00				
MOM OF INERTIA	ROLL=	3004.	PITCH=	39578.	YAW=	40600.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-89.				
CAB/AIRLK	286.	930.	0.	470.	40.	62.	69.	0	873.	1076.
PWR/COOL TR	855.	1076.	0.	425.	16.	21.	16.	0	1056.	1136.
NLG BAY	53.	291.	0.	210.	15.	40.	41.	0	227.	356.
MLG BAY LE	259.	1695.	-200.	200.	27.	57.	57.	0	1605.	1785.
MLG BAY RI	259.	1695.	200.	200.	27.	57.	57.	0	1605.	1785.
ACT ELE LE	81.	1960.	-330.	200.	7.	9.	9.	0	1945.	1975.
ACT ELE RI	81.	1960.	330.	200.	7.	9.	9.	0	1945.	1975.
ACT RUDDER	63.	2115.	0.	695.	7.	9.	9.	0	2110.	2140.
ACT SP BK LE	5.	1845.	-120.	330.	7.	9.	9.	0	1830.	1860.
ACT SP BK RI	5.	1845.	120.	330.	7.	9.	9.	0	1830.	1860.
F EQ BAY LE	135.	946.	-80.	385.	31.	65.	61.	0	833.	1076.
F EQ BAY RI	135.	946.	80.	385.	31.	65.	61.	0	833.	1076.
A EQ BAY LE	12.	1845.	-105.	345.	23.	26.	15.	0	1820.	1865.
A EQ BAY RI	12.	1845.	105.	345.	23.	26.	15.	0	1820.	1865.
NLG EQ BAY	182.	291.	0.	226.	39.	42.	53.	0	227.	356.
HYD BAY	36.	1797.	-67.	283.	20.	20.	20.	0	1782.	1812.
CRU ENG LE	207.	1590.	-232.	190.	18.	101.	101.	0	1420.	1760.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY UNITS - INCH

CRU ENG RI	207.	1590.	232.	190.	18.	101.	101.	0	1420.	1760.

INSULATION

W=	2877.0	X=	1267.16	Y=	-.84	Z=	325.05
RAD OF GYRATION		KROLL=	195.42	KPITCH=	473.16	KYAW=	479.36
MOM OF INERTIA		ROLL=	23714.	PITCH=	139027.	YAW=	142991.
PROD OF INERTIA		ROL-PIT=	-278.	PIT-YAW=	22.	YAW-ROL=	-10921.

CONTINGENCY	648.	930.	0.	408.	8.	8.	8.	0	900.	1060.

CONTINGENCY

W=	648.0	X=	930.00	Y=	.00	Z=	408.00
RAD OF GYRATION		KROL=	8.00	KPIT=	8.00	KYAW=	8.00
MOM OF INERTIA		ROLL=	9.	PITCH=	9.	YAW=	9.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - ENVIR CONTRL

W=	7349.0	X=	1123.89	Y=	-.01	Z=	362.70
RAD OF GYRATION		KROL=	155.81	KPIT=	383.94	KYAW=	380.54
MOM OF INERTIA		ROLL=	41127.	PITCH=	249727.	YAW=	245325.
PROD OF INERTIA		ROL-PIT=	-140.	PIT-YAW=	-28.	YAW-ROL=	-11183.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
SEAT=C PILOT	80.	936.	-21.	464.	17.	17.	9.	0	921.	946.
SEAT=PILOT	80.	936.	21.	464.	17.	17.	9.	0	921.	946.
S.BELT=C.PLT	3.	936.	-21.	457.	4.	4.	4.	0	951.	946.
S.BELT=PLT	3.	936.	21.	457.	4.	4.	4.	0	951.	946.
CREW SEATS										
W= 167.2	X=	936.00	Y=	0.00	Z=	463.73				
RAD OF GYRATION	KROL=	26.86	KPIT=	16.77	KYAW=	22.81				
MOM OF INERTIA	ROLL=	26.	PITCH=	10.	YAW=	19.				
PROD OF INERTIA	ROL=PIT=	0.	PIT=YAW=	0.	YAW=ROL=	0.				
FOOD STORE	42.	963.	65.	428.	21.	19.	14.	0	946.	979.
OVEN	11.	974.	53.	443.	9.	9.	7.	0	967.	982.
FREEZER	53.	959.	53.	443.	9.	9.	7.	0	951.	967.
H2O HTR=CLR	11.	968.	57.	489.	2.	4.	4.	0	960.	975.
H2O TANK	20.	970.	52.	405.	5.	5.	5.	0	965.	975.
LIFE SUPT										
W= 135.5	X=	963.72	Y=	56.88	Z=	436.31				
RAD OF GYRATION	KROL=	24.73	KPIT=	24.10	KYAW=	11.99				
MOM OF INERTIA	ROLL=	18.	PITCH=	17.	YAW=	4.				
PROD OF INERTIA	ROL=PIT=	-0.	PIT=YAW=	-0.	YAW=ROL=	-0.				

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

EMER EQUIP	32.	979.	0.	465.	0.	0.	0.	0	449.	1009.

EMER EQUIP

W= 31.5	X=	979.00	Y=	0.00	Z=	465.00
RAD OF GYRATION	KROLL=	0.00	KPIT=	0.00	KYAW=	0.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

PRIV CURT	3.	979.	-48.	453.	14.	19.	12.	0	949.	1009.
PART-WMA	4.	960.	-54.	431.	23.	25.	21.	0	949.	1009.
PART-FMA	8.	970.	52.	447.	23.	25.	21.	0	949.	1009.
LOCKERS	29.	1034.	-54.	456.	15.	18.	15.	0	1011.	1056.
P.S.STORE	18.	1065.	-54.	459.	15.	18.	9.	0	1056.	1074.
EQ.CABNT	34.	955.	-64.	431.	20.	18.	15.	0	945.	967.

FURNISH

W= 95.8	X=	1001.39	Y=	-48.01	Z=	445.81
RAD OF GYRATION	KROLL=	38.25	KPIT=	50.23	KYAW=	56.70
MOM OF INERTIA	ROLL=	30.	PITCH=	52.	YAW=	66.
PROD OF INERTIA	ROL-PIT=	-3.	PIT-YAW=	1.	YAW-ROL=	11.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - PERSNL PROV

W=	430.0	X=	962.45	Y=	7.23	Z=	451.19
RAD OF GYRATION		KROL=	49.31	KPIT=	40.44	KYAW=	55.45
MOM OF INERTIA		ROLL=	226.	PITCH=	152.	YAW=	285.
PROD OF INERTIA		ROL-PIT=	-39.	PIT-YAW=	-18.	YAW-ROL=	-5.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

SUB-TOTAL - ABORT

W=	.0	X=	.00	Y=	.00	Z=	.00
RAD OF GYRATION		KROL=	.00	KPIT=	.00	KYAW=	.00
MOM OF INERTIA		ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - BALLAST

W=	.0	X=	.00	Y=	.00	Z=	.00
RAD OF GYRATION		KROL=	.00	KPIT=	.00	KYAW=	.00
MOM OF INERTIA		ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

GRØWTH/UNCER 25363. 1479. 0. 269. 0. 0. 0. 0 177. 2100.

GRØWTH/UNCER

W= 25363.0	X=	1479.00	Y=	0.00	Z=	269.00
RAD ØF GYRATIØN	KRØL=	0.00	KPIT=	0.90	KYAW=	0.90
MØM ØF INERTIA	RØLL=	0.	PITCH=	4.	YAW=	4.
PRØD ØF INERTIA	RØL-PIT=	0.	PIT-YAW=	0.	YAW-RØL=	1.

SUB-TOTAL - GROWTH/UNCER

W= 25363.0	X=	1479.00	Y=	.00	Z=	269.00
RAD OF GYRATION	KROL=	.00	KPIT=	.90	KYAW=	.90
MOM OF INERTIA	ROLL=	0.	PITCH=	4.	YAW=	4.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	1.

ACCUM. TØTAL = DRY WEIGHT

W= 224142.1	X=	1479.44	Y=	-0.17	Z=	269.36
RAD ØF GYRATIØN	KRØL=	190.37	KPIT=	486.18	KYAW=	497.83
MØM ØF INERTIA	RØLL=	1753238.	PITCH=	11435534.	YAW=	11990013.
PRØD ØF INERTIA	RØL-PIT=	-11034.	PIT-YAW=	1586.	YAW-RØL=	167466.

C.G. AS % L = 67.7 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES (INCHES)
65K EASTERLY MISSION UNITS = INCH										
CMD PILOT	196.	930.	-21.	458.	15.	18.	8.	0	930.	936.
PILOT	196.	930.	21.	458.	15.	18.	8.	0	930.	936.
CON WEAR GAR	1.	930.	-21.	458.	14.	16.	8.	0	930.	936.
CON WEAR GAR	1.	930.	21.	458.	14.	16.	8.	0	930.	936.
HELMET	6.	936.	-21.	483.	3.	3.	3.	0	930.	936.
HELMET	6.	936.	21.	483.	3.	3.	3.	0	930.	936.
PRESS SUIT	13.	930.	-21.	458.	14.	16.	8.	0	930.	936.
PRESS SUIT	13.	930.	21.	458.	14.	16.	8.	0	930.	936.
HEADSET	1.	936.	-21.	483.	3.	3.	3.	0	930.	936.
HEADSET	1.	936.	21.	483.	3.	3.	3.	0	930.	936.
CREW										
W= 433.0	X=	930.18	Y=	0.00	Z=	458.73				
RAD OF GYRATION	KROLL=	25.99	KPIT=	18.07	KYAW=	22.40				
MOM OF INERTIA	ROLL=	63.	PITCH=	31.	YAW=	47.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				
PERS EQ-FMA	2.	952.	58.	446.	10.	9.	7.	0	946.	958.
PERS EQ-LKR	10.	1034.	-54.	456.	15.	18.	15.	0	1011.	1056.
PROT GAR-LKR	25.	1034.	-54.	456.	15.	18.	15.	0	1011.	1056.
HYG EQ-WMA	16.	959.	-68.	420.	13.	13.	13.	0	951.	967.
PERSONAL GR										
W= 53.0	X=	1008.46	Y=	-54.92	Z=	444.63				
RAD OF GYRATION	KROLL=	30.24	KPIT=	42.68	KYAW=	43.83				
MOM OF INERTIA	ROLL=	10.	PITCH=	21.	YAW=	22.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	1.	YAW-ROL=	6.				

65K EASTERLY MISSION UNITS = INCH

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
FOOD & PKG	59.	969.	61.	440.	9.	8.	8.	0	960.	978.
REC EQUIP	3.	955.	-57.	447.	10.	10.	10.	0	945.	965.
MEDICAL EQ	8.	955.	-57.	447.	10.	10.	10.	0	945.	965.
SURVIVAL KIT	45.	1065.	-54.	459.	15.	18.	9.	0	1056.	1074.

LIFE SUPT

W= 115.0	X=	1005.03	Y=	4.71	Z=	448.08
RAD OF GYRATION	KROL=	59.65	KPIT=	50.61	KYAW=	75.67
MOM OF INERTIA	ROLL=	88.	PITCH=	64.	YAW=	142.
PROD OF INERTIA	ROL-PIT=	-52.	PIT-YAW=	-12.	YAW-ROL=	10.

ACCESS	25.	952.	58.	446.	10.	9.	7.	0	946.	958.

ACCESS

W= 25.0	X=	952.00	Y=	58.00	Z=	446.00
RAD OF GYRATION	KROL=	10.00	KPIT=	9.00	KYAW=	7.00
MOM OF INERTIA	ROLL=	1.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - PERSONNEL

W= 626.0	X=	951.43	Y=	-1.47	Z=	455.07
RAD OF GYRATION	KROL=	40.31	KPIT=	44.72	KYAW=	55.41
MOM OF INERTIA	ROLL=	220.	PITCH=	270.	YAW=	415.
PROD OF INERTIA	ROL-PIT=	-82.	PIT-YAW=	-8.	YAW-ROL=	-6.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

CARGO 40000. 1420. 0. 400. 64. 218. 218. 0 1120. 1840.

LANDED CARGO

W= 40000.0	X=	1420.00	Y=	0.00	Z=	400.00
RAD OF GYRATION	KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA	ROLL=	35363.	PITCH=	410304.	YAW=	410304.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - LANDED CARGO

W= 40000.0	X=	1420.00	Y=	.00	Z=	400.00
RAD OF GYRATION	KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA	ROLL=	35363.	PITCH=	410304.	YAW=	410304.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

65K EASTERLY MISSION UNITS - INCH

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES
A RESID LB	307.	742.	-50.	228.	1.	1.	1.	0	387.	926.
A RESID RB	307.	742.	50.	228.	1.	1.	1.	0	387.	926.
A RESID LH	57.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
A RESID RH	58.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
STAGE PNEU	8.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
BAMS LB	396.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
BAMS LB	397.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
BAMS H	551.	870.	0.	360.	1.	1.	1.	0	628.	1070.
BAMS HE	86.	956.	0.	365.	1.	1.	1.	0	936.	972.
ECS RESID	621.	1000.	0.	440.	100.	200.	200.	0	800.	1400.
HYD FLD	1087.	1900.	0.	200.	200.	200.	25.	0	1600.	2000.
GEAR BIL N	42.	388.	0.	140.	1.	1.	1.	0	384.	392.
GEAR BIL LM	42.	1600.	-210.	110.	1.	1.	1.	0	1595.	1605.
GEAR BIL RM	42.	1600.	210.	110.	1.	1.	1.	0	1595.	1605.

RESID FLUIDS

W= 4001.0	X=	1384.76	Y=	0.04	Z=	278.99
RAD OF GYRATION	KROL=	153.35	KPIT=	540.10	KYAW=	525.29
MOM OF INERTIA	ROLL=	20307.	PITCH=	251910.	YAW=	238289.
PROD OF INERTIA	ROL=PIT=	9.	PIT=YAW=	-.1.	YAW=ROL=	-19508.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS • INCH

SUB-TOTAL - RESID FLUIDS

W=	4001.0	X=	1384.76	Y=	.04	Z= 278.99
RAD OF GYRATION		KROL=	153.35	KPIT=	540.10	KYAW= 525.29
MOM OF INERTIA		ROLL=	20307.	PITCH=	251910.	YAW= 238289.
PROD OF INERTIA		ROL-PIT=	9.	PIT-YAW=	-1.	YAW-ROL= -19508.

ACCUM. TOTAL • INERT WEIGHT

W=	268768.9	X=	1467.95	Y=	-0.14	Z= 289.38
RAD OF GYRATION		KROL=	182.78	KPIT=	460.38	KYAW= 468.03
MOM OF INERTIA		ROLL=	1937966.	PITCH=	12295417.	YAW= 12707588.
PROD OF INERTIA		ROL-PIT=	-11100.	PIT-YAW=	1708.	YAW-ROL= 80218.

C.G. AS % L = 67.1 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES

65K EASTERLY MISSION UNITS - INCH

ENT ACS LB	647.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS RB	648.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS H	367.	870.	0.	360.	1.	1.	1.	0	628.	1070.
AUX RESER BL	1991.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
AUX RESER BR	1991.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
AUX RESER H	738.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	19.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
ECS RES	102.	850.	0.	445.	1.	1.	1.	0	840.	860.
HYD APU LB	33.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RB	33.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	82.	870.	0.	360.	1.	1.	1.	0	628.	1070.

RESERVE FLDS

W=	6651.0	X=	1711.91	Y=	0.01	Z=	287.08
RAD OF GYRATION		KROLL=	89.63	KPIT=	415.57	KYAW=	421.27
MOM OF INERTIA		ROLL=	11532.	PITCH=	247914.	YAW=	254765.
PROD OF INERTIA		ROL-PIT=	4.	PIT-YAW=	-0.	YAW-ROL=	-23211.

SUB-TOTAL - RESERVE FLDS

W=	6651.0	X=	1711.91	Y=	.01	Z=	287.08
RAD OF GYRATION		KROL=	89.63	KPIT=	415.57	KYAW=	421.27
MOM OF INERTIA		ROLL=	11532.	PITCH=	247914.	YAW=	254765.
PROD OF INERTIA		ROL-PIT=	4.	PIT-YAW=	-0.	YAW-ROL=	-23211.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS - INCH

ACCUM. TOTAL - LANDING WT

W= 275420.2	X=	1473.81	Y=	-.14	Z=	289.33
RAD OF GYRATION	KROL=	181.09	KPIT=	460.79	KYAW=	468.38
MOM OF INERTIA	ROLL=	1949510.	PITCH=	12622179.	YAW=	13041177.
PROD OF INERTIA	ROL-PIT=	-11043.	PIT-YAW=	1707.	YAW-ROL=	55478.

C.G. AS % L = 67.4 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
65K EASTERLY MISSION UNITS = INCH										
MAIN STRUT R	1065.	1681.	198.	162.	17.	39.	39.	0	1614.	1747.
MAIN STRUT L	1065.	1681.	-198.	162.	17.	39.	39.	0	1614.	1747.
MAIN AXLE RH	127.	1747.	198.	173.	9.	16.	16.	0	1719.	1775.
MAIN AXLE LH	127.	1747.	-198.	173.	9.	16.	16.	0	1719.	1775.
ATT FTG RH	137.	1614.	198.	151.	25.	5.	25.	0	1600.	1628.
ATT FTG LH	137.	1614.	-198.	151.	25.	5.	25.	0	1600.	1628.
WHL INBD RH	182.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
WHL INBD LH	182.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
WHL OUTBD RH	182.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
WHL OUTBD LH	182.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
BKE INBD RH	303.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
BKE INBD LH	303.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
BKE OUTBD RH	303.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
BRK OUTBD LH	303.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
TIRE INBD RH	263.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
TIRE INBD LH	263.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
TIRE OUTBD R	263.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
TIRE OUTBD L	263.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
AIR INBD RH	20.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
AIR INBD LH	20.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
AIR OUTBD RH	20.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
AIR OUTBD LH	20.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
CONTROL RH	422.	1681.	198.	173.	17.	39.	39.	0	1614.	1747.
CONTROL LH	422.	1681.	-198.	173.	17.	39.	39.	0	1614.	1747.
ANTI SKID RH	25.	1747.	198.	162.	20.	20.	20.	0	1721.	1774.
ANTI SKID LH	25.	1747.	-198.	162.	20.	20.	20.	0	1721.	1774.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS • INCH

MAIN GEAR

W= 6624.0	X= 1711.87	Y= 0.00	Z= 168.47
RAD OF GYRATION	KROL= 199.32	KPIT= 48.66	KYAW= 204.19
MOM OF INERTIA	ROLL= 56799.	PITCH= 3385.	YAW= 59611.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 279.

MAIN GEAR EX	-6624.	1611.	0.	53.	203.	43.	199.	0	1580.	1710.

EXT VS RET

W= -6624.0	X= 1611.00	Y= 0.00	Z= 53.00
RAD OF GYRATION	KROL= 203.00	KPIT= 43.00	KYAW= 199.00
MOM OF INERTIA	ROLL= -58918.	PITCH= -2644.	YAW= -56619.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

NG STRUT	480.	329.	0.	193.	50.	39.	39.	0	257.	390.
ATT FTG NG	53.	390.	0.	178.	50.	3.	50.	0	380.	400.
NG AXLE	30.	258.	0.	208.	50.	1.	50.	0	255.	261.
WHL RH NG	29.	258.	9.	208.	11.	10.	11.	0	240.	275.
WHL LH NG	29.	258.	-9.	208.	11.	10.	11.	0	240.	275.
TIRE RH NG	56.	258.	9.	208.	11.	10.	11.	0	240.	275.
TIRE LH NG	56.	258.	-9.	208.	11.	10.	11.	0	240.	275.
AIR RH NG	3.	258.	9.	208.	11.	10.	11.	0	240.	275.
AIR LHNG	3.	258.	-9.	208.	11.	10.	11.	0	240.	275.
CONTROLS NG	237.	329.	0.	193.	50.	39.	39.	0	257.	390.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

NOSE GEAR

W= 976.0	X= 317.33	Y= 0.00	Z= 195.35
RAD OF GYRATION	KROLL= 46.26	KPIT= 48.17	KYAW= 49.96
MOM OF INERTIA	ROLL= 451.	PITCH= 489.	YAW= 526.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -52.

NOSE GEAR EX	-976.	379.	0.	112.	54.	44.	37.	0	350.	390.

NG EXT VS RE

W= -976.0	X= 379.00	Y= 0.00	Z= 112.00
RAD OF GYRATION	KROL= 54.00	KPIT= 44.00	KYAW= 37.00
MOM OF INERTIA	ROLL= -614.	PITCH= -408.	YAW= -288.
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= 0.

GEAR OIL N	-42.	388.	0.	140.	1.	1.	1.	0	384.	392.
GEAR OIL LM	-42.	1600.	-210.	110.	1.	1.	1.	0	1595.	1605.
GEAR OIL RM	-42.	1600.	210.	110.	1.	1.	1.	0	1595.	1605.
GEAR OIL N	42.	1675.	-210.	175.	1.	1.	1.	0	640.	720.
GEAR OIL LM	42.	1675.	210.	175.	1.	1.	1.	0	640.	720.
GEAR OIL N	42.	340.	0.	195.	1.	1.	1.	0	300.	380.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

HYD APU LB	8.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RB	8.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	21.	870.	0.	360.	1.	1.	1.	0	628.	1070.

CRUISE PROP

W=	37.0	X=	1321.89	Y=	0.00	Z=	320.22
RAD OF GYRATION	KROL=	74.19	KPIT=	519.71	KYAW=	521.01	
MOM OF INERTIA	ROLL=	44.	PITCH=	2157.	YAW=	2168.	
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-188.	

ACCUM. TOTAL = CRUISE PROP

ACCUM. TOTAL = FLIGHT WT

W=	275456.9	X=	1476.04	Y=	-0.14	Z=	292.43
RAD OF GYRATION	KROL=	177.94	KPIT=	461.27	KYAW=	470.05	
MOM OF INERTIA	ROLL=	1882500.	PITCH=	12650012.	YAW=	13136205.	
PROD OF INERTIA	ROL-PIT=	-11024.	PIT-YAW=	1733.	YAW-ROL=	42521.	

C.G. AS % L = 67.6 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

HYD APU L0	142.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU R0	142.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	352.	870.	0.	360.	1.	1.	1.	0	628.	1070.
0AMS L0SS H	160.	870.	0.	360.	1.	1.	1.	0	628.	1070.
C0LD HE	38.	956.	0.	365.	1.	1.	1.	0	936.	972.
ENT ACS L0	390.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS R0	389.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS H	221.	870.	0.	360.	1.	1.	1.	0	628.	1070.

ENTRY ACS

W= 1834.0	X=	1477.47	Y=	-0.05	Z=	306.78
RAD 0F GYRATI0N	KR0L=	81.65	KPIT=	515.90	KYAW=	518.33
M0M 0F INERTIA	R0LL=	2639.	PITCH=	105356.	YAW=	106352.
PR0D 0F INERTIA	R0L-PIT=	-8.	PIT-YAW=	1.	YAW-R0L=	-9257.

ACCUM. T0TAL = ENTRY ACS

ACCUM. T0TAL = ENTRY WT

W= 277290.9	X=	1476.05	Y=	-0.14	Z=	292.52
RAD 0F GYRATI0N	KR0L=	177.48	KPIT=	461.65	KYAW=	470.39
M0M 0F INERTIA	R0LL=	1885216.	PITCH=	12755561.	YAW=	13242669.
PR0D 0F INERTIA	R0L-PIT=	-11033.	PIT-YAW=	1734.	YAW-R0L=	33270.

C.G. AS % L = 67.6 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

DEORBIT OL	2306.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
DEORBIT OR	2307.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
DEORBIT M	923.	870.	0.	360.	1.	1.	1.	0	628.	1070.

RETRO PROP

W= 5536.0	X=	1740.77	Y=	0.02	Z=	283.34
RAD OF GYRATION	KROL=	88.19	KPIT=	391.01	KYAW=	397.69
MOM OF INERTIA	ROLL=	9293.	PITCH=	182688.	YAW=	189170.
PROD OF INERTIA	ROL*PIT=	3.	PIT*YAW=	-0.	YAW*ROL=	-15960.

ACCUM. TOTAL = RETRO PROP

ACCUM. TOTAL = PRE RETRO WT

W= 282826.9	X=	1481.23	Y=	-0.14	Z=	292.34
RAD OF GYRATION	KROL=	176.17	KPIT=	461.83	KYAW=	470.50
MOM OF INERTIA	ROLL=	1894611.	PITCH=	13020459.	YAW=	13513942.
PROD OF INERTIA	ROL*PIT=	-10981.	PIT*YAW=	1732.	YAW*ROL=	14457.

C.G. AS % L = 67.8 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
65K EASTERLY MISSION UNITS = INCH										
ASCENT LGBX	31.	742.	-50.	228.	1.	1.	1.	0	387.	926.
ASCENT RGBX	30.	742.	50.	228.	1.	1.	1.	0	387.	926.
ASCENT LGH	17.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
ASCENT RGH	18.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
MANEU BL	3397.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
MANEU BR	3396.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
MANEU H	1525.	870.	0.	360.	1.	1.	1.	0	628.	1070.
ECS N	67.	850.	0.	445.	1.	1.	1.	0	840.	860.
ECS BL	11.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ECS BR	12.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ECS H	234.	870.	0.	360.	1.	1.	1.	0	628.	1070.
EPS BL	284.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
EPS BR	285.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
EPS H	71.	870.	0.	360.	1.	1.	1.	0	628.	1070.
ACS BL	259.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ACS BR	258.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ACS H	146.	870.	0.	360.	1.	1.	1.	0	500.	1080.
CBLD HE	25.	956.	0.	365.	1.	1.	1.	0	936.	972.
BAMS LBSS LB	13.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
BAMS LBSS RB	13.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
BAMS LBSS H	1268.	870.	0.	360.	1.	1.	1.	0	628.	1070.

BN BRB LBSS

W= 11360.0	X= 1600.09	Y= 0.00	Z= 295.19		
RAD OF GYRATION	KROLL= 86.31	KPITCH= 481.40	KYAW= 485.18		
MOM OF INERTIA	ROLL= 18267.	PITCH= 568230.	YAW= 577194.		
PROD OF INERTIA	ROL-PIT= 6.	PIT-YAW= -0.	YAW-ROL= -48754.		

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

ACCUM. TOTAL = ON ORB LOSS

CARGO *40000. 1420. 0. 400. 64. 218. 218. 0 1120. 1840.

LANDED CARGO

W= *40000.0 X= 1420.00 Y= 0.00 Z= 400.00
RAD OF GYRATION KROLL= 64.00 KPIT= 218.00 KYAW= 218.00
MOM OF INERTIA ROLL= *35363. PITCH= *410304. YAW= *410304.
PROD OF INERTIA ROL*PIT= 0. PIT*YAW= 0. YAW*ROL= 0.

ACCUM. TOTAL = LANDED CARGO

CARGO 65000. 1420. 0. 400. 64. 218. 218. 0 1120. 1840.

ASCENT CARGO

W= 65000.0 X= 1420.00 Y= 0.00 Z= 400.00
RAD OF GYRATION KROLL= 64.00 KPIT= 218.00 KYAW= 218.00
MOM OF INERTIA ROLL= 57465. PITCH= 666744. YAW= 666744.
PROD OF INERTIA ROL*PIT= 0. PIT*YAW= 0. YAW*ROL= 0.

ACCUM. TOTAL = ASCENT CARGO

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

ACCUM. TOTAL = ON ORBIT WT

W= 319186.9	X= 1480.67	Y= -0.12	Z= 300.88			
RAD OF GYRATION	KROL= 170.06	KPIT= 450.11	KYAW= 457.23			
MOM OF INERTIA	ROLL= 1992526.	PITCH= 13957666.	YAW= 14402571.			
PROD OF INERTIA	ROL-PIT= -10980.	PIT-YAW= 1803.	YAW-ROL= -68704.			

C.G. AS % L = 67.8 %

MANEU OL	831.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
MANEU OR	830.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
MANEU H	332.	870.	0.	360.	1.	1.	1.	0	628.	1070.

MANEUV PROP

W= 1993.0	X= 1740.92	Y= -0.04	Z= 283.33							
RAD OF GYRATION	KROL= 88.19	KPIT= 390.88	KYAW= 397.76							
MOM OF INERTIA	ROLL= 3346.	PITCH= 65724.	YAW= 68058.							
PROD OF INERTIA	ROL-PIT= -3.	PIT-YAW= 0.	YAW-ROL= -5741.							

ACCUM. TOTAL = MANEUV PROP

RESER OL	2772.	742.	-50.	228.	1.	1.	1.	0	387.	926.
RESER OR	2771.	742.	50.	228.	1.	1.	1.	0	387.	926.
RESER HL	462.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
RESER HR	462.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
DUMPED OL	1894.	742.	-30.	228.	1.	1.	1.	0	387.	826.
DUMPED OR	1894.	742.	30.	228.	1.	1.	1.	0	387.	926.
DUMPED HL	172.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES

65K EASTERLY MISSION UNITS = INCH

DUMPED HR	173.	1331.	60.	228.	1.	1.	1.	0	926.	1739.

DUMPED PROP

W= 10600.0	X=	812.51	Y=	0.00	Z=	228.00
RAD OF GYRATION	KROLL=	45.40	KPIT=	191.21	KYAW=	196.52
MOM OF INERTIA	ROLL=	4715.	PITCH=	83648.	YAW=	88361.
PROD OF INERTIA	ROL*PIT=	7.	PIT*YAW=	.0.	YAW*ROL=	.0.

ACCUM. TOTAL = DUMPED PROP

ACCUM. TOTAL = INJECTION WT

W= 331779.9	X=	1460.88	Y=	.0.12	Z=	298.44
RAD OF GYRATION	KROLL=	167.64	KPIT=	459.82	KYAW=	466.46
MOM OF INERTIA	ROLL=	2012443.	PITCH=	15141381.	YAW=	15581484.
PROD OF INERTIA	ROL*PIT=	.11147.	PIT*YAW=	1783.	YAW*ROL=	31558.

C.G. AS % L = 66.8 %

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS = INCH

BAMS LOSS H	35.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
SHUTDN LO	88.	742.	-50.	228.	1.	1.	1.	0	387.	926.
SHUTDN RO	88.	742.	50.	228.	1.	1.	1.	0	387.	926.
SHUTDN LH	40.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
SHUTDN RH	40.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
MAIN LO	56385.	890.	-60.	228.	1.	1.	1.	0	845.	926.
MAIN RO	56385.	890.	60.	228.	1.	1.	1.	0	845.	926.
MAIN LH	9397.	1637.	-60.	228.	1.	1.	1.	0	1535.	1739.
MAIN RH	9397.	1637.	60.	228.	1.	1.	1.	0	1535.	1739.

ASCENT PROP

W= 131860.0	X= 996.57	Y= 0.00	Z= 228.04		
RAD OF GYRATION	KROL= 60.03	KPIT= 261.46	KYAW= 268.25		
MOM OF INERTIA	ROLL= 102562.	PITCH= 1945638.	YAW= 2047904.		
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -103.		

ACCUM. TOTAL = ASCENT PROP

ACCUM. TOTAL = 75% BURN

W= 463639.9	X= 1328.83	Y= -0.08	Z= 278.42		
RAD OF GYRATION	KROL= 148.81	KPIT= 464.36	KYAW= 469.09		
MOM OF INERTIA	ROLL= 2215977.	PITCH= 21578784.	YAW= 22020160.		
PROD OF INERTIA	ROL-PIT= -12250.	PIT-YAW= 1616.	YAW-ROL= 697279.		

C.G. AS % L = 59.9 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

HYD APU LB	29.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RB	30.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	73.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN LB	56384.	797.	-55.	228.	1.	1.	1.	0	742.	845.
MAIN RB	56384.	797.	55.	228.	1.	1.	1.	0	742.	845.
MAIN LH	9398.	1433.	-60.	228.	1.	1.	1.	0	1331.	1535.
MAIN RH	9398.	1433.	60.	228.	1.	1.	1.	0	1331.	1535.

ASCENT PROP

W= 131701.0	X=	888.35	Y=	0.00	Z= 228.09
RAD OF GYRATION	KROL=	55.85	KPIT=	223.60	KYAW= 230.43
MOM OF INERTIA	ROLL=	88675.	PITCH=	1421280.	YAW= 1509330.
PROD OF INERTIA	ROL-PIT=	20.	PIT-YAW=	1.	YAW-ROL= 514.

ACCUM. TOTAL = ASCENT PROP

ACCUM. TOTAL = 50% BURN

W= 595340.9	X=	1231.39	Y=	-0.06	Z= 267.29
RAD OF GYRATION	KROL=	135.54	KPIT=	461.36	KYAW= 465.34
MOM OF INERTIA	ROLL=	2360721.	PITCH=	27351376.	YAW= 27824752.
PROD OF INERTIA	ROL-PIT=	-13050.	PIT-YAW=	1523.	YAW-ROL= 1188531.

C.G. AS % L = 54.8 %

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

65K EASTERLY MISSION UNITS • INCH

STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN L8	56385.	685.	-45.	228.	1.	1.	1.	0	613.	742.
MAIN R8	56385.	685.	45.	228.	1.	1.	1.	0	613.	742.
MAIN LH	9397.	1230.	-60.	228.	1.	1.	1.	0	1128.	1331.
MAIN RH	9397.	1230.	60.	228.	1.	1.	1.	0	1128.	1331.

ASCENT PR8P

W= 131569.0	X=	762.89	Y=	0.00	Z=	228.00
RAD 8F GYRATI8N	KR8L=	47.45	KPIT=	190.82	KYAW=	196.63
M8M 8F INERTIA	R8LL=	63938.	PITCH=	1034027.	YAW=	1097928.
PR8D 8F INERTIA	R8L-PIT=	0.	PIT-YAW=	0.	YAW-R8L=	27.

ACCUM. T8TAL • ASCENT PR8P

ACCUM. T8TAL • 25% BURN

W= 726909.9	X=	1146.59	Y=	-0.05	Z=	260.18
RAD 8F GYRATI8N	KR8L=	125.23	KPIT=	462.26	KYAW=	465.70
M8M 8F INERTIA	R8LL=	2460560.	PITCH=	33526304.	YAW=	34027664.
PR8D 8F INERTIA	R8L-PIT=	-13756.	PIT-YAW=	1464.	YAW-R8L=	1616625.

C.G. AS % L = 50.4 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

65K EASTERLY MISSION UNITS = INCH

STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN LB	56385.	520.	-53.	228.	1.	1.	1.	0	387.	613.
MAIN RB	56384.	520.	53.	228.	1.	1.	1.	0	387.	613.
MAIN LH	9398.	1026.	-60.	228.	1.	1.	1.	0	926.	1128.
MAIN RH	9398.	1026.	60.	228.	1.	1.	1.	0	926.	1128.

ASCENT PROP

W= 131570.0	X=	592.34	Y=	-0.00	Z=	228.00
RAD OF GYRATION	KROLL=	54.07	KPIT=	177.23	KYAW=	185.29
MOM OF INERTIA	ROLL=	83021.	PITCH=	892012.	YAW=	974999.
PROD OF INERTIA	ROL-PIT=	1.	PIT-YAW=	0.	YAW-ROL=	34.

ACCUM. TOTAL = ASCENT PROP

ACCUM. TOTAL = IGNITION

W= 858479.9	X=	1061.65	Y=	-0.05	Z=	255.24
RAD OF GYRATION	KROLL=	117.73	KPIT=	475.13	KYAW=	478.30
MOM OF INERTIA	ROLL=	2568459.	PITCH=	41829904.	YAW=	42389392.
PROD OF INERTIA	ROL-PIT=	-14457.	PIT-YAW=	1423.	YAW-ROL=	2045454.

C.G. AS % L = 46.0 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

65K EASTERLY MISSION UNITS = INCH

MAIN LB	782.	742.	-50.	228.	1.	1.	1.	0	387.	926.
MAIN RB	782.	742.	50.	228.	1.	1.	1.	0	387.	926.
MAIN LH	199.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
MAIN RH	199.	1331.	60.	228.	1.	1.	1.	0	926.	1739.

STARTUP

W= 1962.0	X=	861.48	Y=	0.00	Z=	228.00
RAD OF GYRATION	KROL=	52.19	KPIT=	236.85	KYAW=	242.53
MOM OF INERTIA	ROLL=	1154.	PITCH=	23757.	YAW=	24910.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ACCUM. TOTAL = STARTUP

ACCUM. TOTAL = LAUNCH WT

W= 860441.9	X=	1061.19	Y=	-0.04	Z=	255.18
RAD OF GYRATION	KROL=	117.63	KPIT=	474.82	KYAW=	477.99
MOM OF INERTIA	ROLL=	2569926.	PITCH=	41870784.	YAW=	42431120.
PROD OF INERTIA	ROL-PIT=	-14461.	PIT-YAW=	1423.	YAW-ROL=	2047760.

C.G. AS % L = 46.0 %

Appendix B

This appendix contains the detail build-up of component weight, center-of-gravity, moment of inertia and product of inertia for the 25K 55 degree mission w/ABES. To reduce the volume of this report only the differences from the easterly mission have been shown in this appendix. If data is required on a subsystem not in this appendix, then see Appendix A.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
25K 55 DEG MISSION W/ABES

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y (INCH)	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	31587.	1738.	0.	194.	549.	423.	962.
					0.	0.	4.
TAILS	5104.	2054.	0.	632.	2.	11.	11.
					0.	0.	2.
BODY	55500.	1292.	0.	291.	191.	2605.	2551.
					0.	0.	82.
THERMAL PROT	32847.	1353.	-0.	191.	388.	2734.	3095.
					-0.	-0.	-6.
LANDING/DOCK	10551.	1438.	-0.	129.	102.	432.	452.
					-0.	-0.	-36.
PROP-ASCENT	26637.	1863.	4.	320.	42.	416.	395.
					-3.	-1.	3.
PROP-CRUISE	15273.	1593.	1.	123.	219.	36.	237.
					-0.	0.	6.
PROP-AUXIL	11877.	1291.	6.	320.	31.	677.	691.
					-0.	1.	-28.
PRIME POWER	2272.	1015.	-31.	258.	1.	264.	265.
					-12.	-0.	9.
ELEC DIST	1303.	832.	-16.	235.	0.	48.	48.
					-2.	-0.	2.
HYDRA DIST	2760.	1705.	-52.	262.	5.	42.	45.
					-2.	-0.	3.
SURF CONTROL	4901.	1944.	0.	308.	92.	33.	71.
					0.	0.	7.
AVIONICS	4588.	1030.	1.	384.	12.	101.	99.
					1.	-0.	-5.
ENVIR CONTRL	7849.	1124.	0.	363.	41.	250.	245.
					-0.	-0.	-11.
PERSNL PROV	430.	962.	7.	451.	0.	0.	0.
					-0.	-0.	-0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	21718.	1488.	0.	259.	0.	0.	0.
					0.	0.	0.
DRY WEIGHT	235196.	1487.	-0.	259.	2034.	11571.	12260.
					-11.	1.	122.
PERSONNEL	626.	951.	-1.	455.	0.	0.	0.
					-0.	-0.	-0.
LANDED CARGO	25000.	1420.	0.	400.	22.	256.	256.
					0.	0.	0.
RESID FLUIDS	4205.	1389.	0.	282.	22.	253.	239.
					0.	0.	-19.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
25K 55 DEG MISSION W/ABES

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
INERT WEIGHT	265027.	1478.	-0.	273.	2180.	12251.	12824.
					-11.	2.	42.
RESERVE FLDS	8329.	1632.	0.	311.	17.	260.	268.
					0.	0.	-29.
LANDING WT	273356.	1483.	-0.	274.	2199.	12554.	13133.
					-11.	2.	23.
CRUISE PROP	1177.	1968.	0.	1094.	-227.	-201.	31.
					0.	0.	-115.
FLIGHT WT	274533.	1485.	-0.	278.	2142.	12583.	13224.
					-11.	2.	9.
ENTRY ACS	1834.	1476.	-0.	923.	-257.	-123.	75.
					-0.	-0.	14.
ENTRY WT	276367.	1485.	-0.	282.	2049.	12624.	13299.
					-11.	2.	20.
RETRO PROP	9429.	1741.	0.	283.	16.	311.	322.
					0.	0.	-27.
PRE RETRO WT	285796.	1493.	-0.	282.	2065.	13064.	13750.
					-11.	2.	-6.
ON ORB LOSS	7401.	1511.	0.	303.	11.	417.	421.
					0.	-0.	-36.
LANDED CARGO	-25000.	1420.	0.	400.	-22.	-256.	-256.
					0.	0.	0.
ASCENT CARGO	25000.	1420.	0.	400.	22.	256.	256.
					0.	0.	0.
ON ORBIT WT	293197.	1494.	-0.	283.	2077.	13482.	14172.
					-11.	2.	-42.
MANEUV PROP	13529.	1741.	0.	283.	23.	446.	462.
					0.	0.	-39.
DUMPED PROP	10423.	812.	0.	228.	5.	82.	87.
					-0.	0.	-0.
INJECTION WT	317149.	1482.	-0.	281.	2110.	15231.	15934.
					-11.	2.	2.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
25K 55 DEG MISSION W/ABES

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ASCENT PROP	131904.	997.	0.	228.	103.	1946.	2049.
					0.	0.	-0.
75% BURN	449053.	1339.	-0.	265.	2269.	21970.	22720.
					-12.	1.	517.
ASCENT PROP	131746.	888.	0.	228.	89.	1422.	1510.
					0.	0.	1.
50% BURN	580799.	1237.	-0.	257.	2388.	27895.	28703.
					-13.	1.	886.
ASCENT PROP	131615.	763.	0.	228.	64.	1034.	1098.
					0.	0.	0.
25% BURN	712414.	1149.	-0.	252.	2471.	34156.	35008.
					-14.	1.	1203.
ASCENT PROP	131612.	592.	0.	228.	83.	892.	975.
					-0.	0.	0.
IGNITION	844026.	1063.	-0.	248.	2568.	42505.	43426.
					-15.	1.	1517.
STARTUP	1962.	861.	0.	228.	1.	24.	25.
					0.	0.	0.
LAUNCH WT	845988.	1062.	-0.	248.	2569.	42546.	43468.
					-15.	1.	1519.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
25K 55 DEG MISSION		UNITS = INCH								
ENGINE 8BLH	2665.	1681.	-337.	131.	16.	30.	30.	0	1609.	1766.
IGN WIRE	8.	1663.	-337.	133.	25.	18.	18.	0	1609.	1766.
HEAT XCHNGR	20.	1667.	-357.	108.	2.	3.	3.	0	1609.	1766.
ACCUM	15.	1667.	-348.	108.	4.	6.	6.	0	1609.	1766.
LINE&VALVE	9.	1666.	-337.	123.	25.	18.	18.	0	1609.	1766.
BLEED AIR	10.	1663.	-337.	133.	25.	18.	18.	0	1609.	1766.
INSTR	18.	1681.	-337.	133.	16.	30.	30.	0	1609.	1766.
STARTER	50.	1639.	-342.	104.	5.	14.	14.	0	1609.	1766.
FIRE EXT	21.	1691.	-337.	176.	2.	4.	9.	0	1609.	1766.
FIRE SENS	2.	1678.	-337.	149.	25.	17.	17.	0	1609.	1766.
LINES&MISC	4.	1678.	-337.	149.	25.	17.	17.	0	1609.	1766.
AIR INDUCT	16.	1627.	-337.	133.	26.	14.	14.	0	1609.	1766.
ENG MTS	110.	1684.	-337.	133.	26.	17.	17.	0	1609.	1766.
NACELLE	213.	1681.	-337.	133.	25.	46.	46.	0	1609.	1766.
PYL8N	179.	1696.	-337.	172.	6.	29.	29.	0	1609.	1766.

ENG & NAC

W=	3337.5	X=	1680.80	Y=	-337.24	Z=	133.06
RAD 8F GYRATION	KR8L=	19.97	KPIT=	33.00	KYAW=	31.25	
M8M 8F INERTIA	R8LL=	287.	PITCH=	784.	YAW=	703.	
PR8D 8F INERTIA	R8L=PIT=	3.	PIT=YAW=	5.	YAW=R8L=	40.	

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

25K 55 DEG MISSION UNITS = INCH

ENGINE IBLH	2665.	1506.	-142.	82.	16.	30.	30.	0	1434.	1591.
IGN WIRE	8.	1488.	-142.	84.	25.	18.	18.	0	1434.	1591.
HEAT XCHNGR	20.	1492.	-162.	59.	2.	3.	3.	0	1434.	1591.
ACCUM	15.	1492.	-153.	59.	4.	6.	6.	0	1434.	1591.
LINE&VALVE	9.	1491.	-142.	74.	25.	18.	18.	0	1434.	1591.
BLEED AIR	10.	1488.	-142.	84.	25.	18.	18.	0	1434.	1591.
INSTR	18.	1506.	-142.	84.	16.	30.	30.	0	1434.	1591.
STARTER	50.	1464.	-147.	56.	5.	14.	14.	0	1434.	1591.
FIRE EXT	21.	1516.	-142.	122.	2.	4.	9.	0	1434.	1591.
FIRE SENS	2.	1503.	-142.	100.	25.	17.	17.	0	1434.	1591.
LINES&MISC	4.	1503.	-142.	100.	25.	17.	17.	0	1434.	1591.
AIR INDUCT	16.	1452.	-142.	84.	26.	14.	14.	0	1434.	1591.
ENG MTS	110.	1509.	-142.	84.	26.	17.	17.	0	1434.	1591.
NACELLE	213.	1506.	-142.	84.	25.	46.	46.	0	1434.	1591.
PYLON	179.	1521.	-142.	123.	6.	29.	29.	0	1434.	1591.

ENG & NAC

W= 3337.5	X=	1505.80	Y=	-142.24	Z=	84.05
RAD OF GYRATION	KROL=	19.88	KPIT=	32.97	KYAW=	31.27
MOM OF INERTIA	ROLL=	285.	PITCH=	783.	YAW=	704.
PROD OF INERTIA	ROL-PIT=	4.	PIT-YAW=	5.	YAW-ROL=	40.

ENGINE OBRH	2665.	1681.	337.	131.	16.	30.	30.	0	1609.	1766.
IGN WIRE	8.	1663.	337.	133.	25.	18.	18.	0	1609.	1766.
HEAT XCHNGR	20.	1667.	357.	108.	2.	3.	3.	0	1609.	1766.
ACCUM	15.	1667.	348.	108.	4.	6.	6.	0	1609.	1766.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS • INCH

LINE&VALVE	9.	1666.	337.	123.	25.	18.	18.	0	1609.	1766.
BLEED AIR	10.	1663.	337.	133.	25.	18.	18.	0	1609.	1766.
INSTR	18.	1681.	337.	133.	16.	30.	30.	0	1609.	1766.
STARTER	50.	1639.	342.	104.	5.	14.	14.	0	1609.	1766.
FIRE EXT	21.	1691.	337.	176.	2.	4.	9.	0	1609.	1766.
FIRE SENS	2.	1678.	337.	149.	25.	17.	17.	0	1609.	1766.
LINES&MISC	4.	1678.	337.	149.	25.	17.	17.	0	1609.	1766.
AIR INDUCT	16.	1627.	337.	133.	26.	14.	14.	0	1609.	1766.
ENG MTS	110.	1684.	337.	133.	26.	17.	17.	0	1609.	1766.
NACELLE	213.	1681.	337.	133.	25.	46.	46.	0	1609.	1766.
PYLON	179.	1696.	337.	172.	6.	29.	29.	0	1609.	1766.

ENG & NAC

W= 3337.5	X=	1680.80	Y=	337.24	Z=	133.06
RAD OF GYRATION	KROLL=	19.97	KPITCH=	33.00	KYAW=	31.25
MOM OF INERTIA	ROLL=	287.	PITCH=	784.	YAW=	703.
PROD OF INERTIA	ROL-PIT=	-3.	PIT-YAW=	-5.	YAW-ROL=	40.

ENGINE IBRH	2665.	1506.	142.	82.	16.	30.	30.	0	1434.	1591.
IGN WIRE	8.	1488.	142.	84.	25.	18.	18.	0	1434.	1591.
HEAT XCHNGR	20.	1492.	162.	59.	2.	3.	3.	0	1434.	1591.
ACCUM	15.	1492.	153.	59.	4.	6.	6.	0	1434.	1591.
LINE&VALVE	9.	1491.	142.	74.	25.	18.	18.	0	1434.	1591.
BLEED AIR	10.	1488.	142.	84.	25.	18.	18.	0	1434.	1591.
INSTR	18.	1506.	142.	84.	16.	30.	30.	0	1434.	1591.
STARTER	50.	1464.	147.	56.	5.	14.	14.	0	1434.	1591.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS = INCH

FIRE EXT	21.	1516.	142.	122.	2.	4.	9.	0	1434.	1591.
FIRE SENS	2.	1503.	142.	100.	25.	17.	17.	0	1434.	1591.
LINES&MISC	4.	1503.	142.	100.	25.	17.	17.	0	1434.	1591.
AIR INDUCT	16.	1452.	142.	84.	26.	14.	14.	0	1434.	1591.
ENG MTS	110.	1509.	142.	84.	26.	17.	17.	0	1434.	1591.
NACELLE	213.	1506.	142.	84.	25.	46.	46.	0	1434.	1591.
PYLON	179.	1521.	142.	123.	6.	29.	29.	0	1434.	1591.

ENG & NAC

W= 3337.5	X=	1505.80	Y=	142.24	Z=	84.05
RAD OF GYRATION	KROL=	19.88	KPIT=	32.97	KYAW=	31.27
MOM OF INERTIA	ROLL=	285.	PITCH=	783.	YAW=	704.
PROD OF INERTIA	ROL-PIT=	.4.	PIT-YAW=	-5.	YAW-ROL=	40.

FUEL SYS	338.	1579.	38.	260.	200.	140.	200.	0	1346.	1818.

PROP SYS

W= 337.5	X=	1579.00	Y=	38.00	Z=	260.00
RAD OF GYRATION	KROL=	200.00	KPIT=	140.00	KYAW=	200.00
MOM OF INERTIA	ROLL=	2914.	PITCH=	1428.	YAW=	2914.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

TANKS&SUPT	88.	1471.	-95.	342.	16.	24.	24.	0	1418.	1526.
TANKS&SUPT	88.	1471.	95.	342.	16.	24.	24.	0	1418.	1526.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

TANKAGE

W= 175.0	X= 1471.00	Y= 0.00	Z= 342.00
RAD OF GYRATION	KROLL= 96.34	KPIT= 24.00	KYAW= 97.98
MOM OF INERTIA	ROLL= 351.	PITCH= 22.	YAW= 363.
PROD OF INERTIA	ROL=PIT= 0.	PIT=YAW= 0.	YAW=ROL= =0.

DEPLOY IBLH	224.	1523.	-140.	182.	6.	10.	10.	0	1434.	1591.
DEPLOY OBLH	224.	1706.	-352.	212.	6.	10.	10.	0	1434.	1591.
DEPLOY IBRH	224.	1523.	140.	182.	6.	10.	10.	0	1434.	1591.
DEPLOY OBRH	224.	1706.	352.	212.	6.	10.	10.	0	1434.	1591.

DEPLOY MECH

W= 894.0	X= 1614.50	Y= 0.00	Z= 197.00
RAD OF GYRATION	KROL= 268.35	KPIT= 93.26	KYAW= 283.24
MOM OF INERTIA	ROLL= 13896.	PITCH= 1678.	YAW= 15480.
PROD OF INERTIA	ROL=PIT= 0.	PIT=YAW= 0.	YAW=ROL= 265.

CONTINGENCY	517.	1593.	0.	197.	0.	0.	0.	0	1434.	1766.

CONTINGENCY

W= 516.5	X= 1593.00	Y= 0.00	Z= 197.00
RAD OF GYRATION	KROL= 0.00	KPIT= 0.00	KYAW= 0.00
MOM OF INERTIA	ROLL= 0.	PITCH= 0.	YAW= 0.
PROD OF INERTIA	ROL=PIT= 0.	PIT=YAW= 0.	YAW=ROL= 0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

25K 55 DEG MISSION W/ABES UNITS - INCH

SUB-TOTAL - PROP-CRUISE

W= 15273.0	X=	1592.81	Y=	.84	Z=	122.74
RAD OF GYRATION	KROL=	257.51	KPIT=	104.74	KYAW=	268.36
MOM OF INERTIA	ROLL=	218595.	PITCH=	36165.	YAW=	237410.
PROD OF INERTIA	ROL-PIT=	-39.	PIT-YAW=	380.	YAW-ROL=	5750.

GROWTH/UNCER	21718.	1488.	0.	259.	0.	0.	0.	0	177.	2100.

GROWTH/UNCER

W= 21718.0	X=	1488.00	Y=	0.00	Z=	259.00
RAD OF GYRATION	KROL=	0.00	KPIT=	0.00	KYAW=	0.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - GROWTH/UNCER

W= 21718.0	X=	1488.00	Y=	.00	Z=	259.00
RAD OF GYRATION	KROL=	.00	KPIT=	.00	KYAW=	.00
MOM OF INERTIA	ROLL=	0.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

25K 55 DEG MISSION UNITS = INCH

ACCUM. TOTAL = DRY WEIGHT

W= 235195.9	X=	1487.48	Y=	-0.17	Z=	258.88
RAD OF GYRATION	KROL=	200.17	KPIT=	477.52	KYAW=	491.51
MOM OF INERTIA	ROLL=	2034019.	PITCH=	11575787.	YAW=	12263987.
PROD OF INERTIA	ROL-PIT=	-10987.	PIT-YAW=	1490.	YAW-ROL=	122442.

C.G. AS % L = 68.1 %

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

25K 55 DEG MISSION UNITS = INCH

CMD PILOT	196.	930.	-21.	458.	15.	18.	8.	0	930.	936.
PILOT	196.	930.	21.	458.	15.	18.	8.	0	930.	936.
CON WEAR GAR	1.	930.	-21.	458.	14.	16.	8.	0	930.	936.
CON WEAR GAR	1.	930.	21.	458.	14.	16.	8.	0	930.	936.
HELMET	6.	936.	-21.	483.	3.	3.	3.	0	930.	936.
HELMET	6.	936.	21.	483.	3.	3.	3.	0	930.	936.
PRESS SUIT	13.	930.	-21.	458.	14.	16.	8.	0	930.	936.
PRESS SUIT	13.	930.	21.	458.	14.	16.	8.	0	930.	936.
HEADSET	1.	936.	-21.	483.	3.	3.	3.	0	930.	936.
HEADSET	1.	936.	21.	483.	3.	3.	3.	0	930.	936.

CREW

W= 433.0	X=	930.18	Y=	0.00	Z=	458.73	
RAD OF GYRATION	KROLL=	25.99	KPIT=	18.07	KYAW=	22.40	
MOM OF INERTIA	ROLL=	63.	PITCH=	31.	YAW=	47.	
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.	

PERS EQ-FMA	2.	952.	58.	446.	10.	9.	7.	0	946.	958.
PERS EQ-LKR	10.	1034.	-54.	456.	15.	18.	15.	0	1011.	1056.
PROT GAR-LKR	25.	1034.	-54.	456.	15.	18.	15.	0	1011.	1056.
HYG EQ-WMA	16.	959.	-68.	420.	13.	13.	13.	0	951.	967.

PERSONAL GR

W= 53.0	X=	1008.46	Y=	-54.92	Z=	444.63	
RAD OF GYRATION	KROLL=	30.24	KPIT=	42.68	KYAW=	43.83	
MOM OF INERTIA	ROLL=	10.	PITCH=	21.	YAW=	22.	
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	1.	YAW-ROL=	6.	

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES) X	Y	Z	RADII OF GYRATION (INCHES) ROLL	PITCH	YAW	DIST. DATA DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

FOOD & PKG	59.	969.	61.	440.	9.	8.	8.	0	960.	978.
REC EQUIP	3.	955.	.57.	447.	10.	10.	10.	0	945.	965.
MEDICAL EQ	8.	955.	.57.	447.	10.	10.	10.	0	945.	965.
SURVIVAL KIT	45.	1065.	.54.	459.	15.	18.	9.	0	1056.	1074.

LIFE SUPT

W= 115.0	X=	1005.03	Y=	4.71	Z=	448.08
RAD OF GYRATION	KROL=	59.65	KPIT=	50.61	KYAW=	75.67
MOM OF INERTIA	ROLL=	88.	PITCH=	64.	YAW=	142.
PROD OF INERTIA	ROL-PIT=	-52.	PIT-YAW=	.12.	YAW-ROL=	10.

ACCESS	25.	952.	58.	446.	10.	9.	7.	0	946.	958.

ACCESS

W= 25.0	X=	952.00	Y=	58.00	Z=	446.00
RAD OF GYRATION	KROL=	10.00	KPIT=	9.00	KYAW=	7.00
MOM OF INERTIA	ROLL=	1.	PITCH=	0.	YAW=	0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - PERSONNEL

W= 626.0	X=	951.43	Y=	-1.47	Z=	455.07
RAD OF GYRATION	KROL=	40.31	KPIT=	44.72	KYAW=	55.41
MOM OF INERTIA	ROLL=	220.	PITCH=	270.	YAW=	415.
PROD OF INERTIA	ROL-PIT=	-82.	PIT-YAW=	-8.	YAW-ROL=	-6.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

25K 55 DEG MISSION UNITS = INCH

CARGO 25000. 1420. 0. 400. 64. 218. 218. 0 1120. 1840.

LANDED CARGO

W= 25000.0	X=	1420.00	Y=	0.00	Z=	400.00
RAD OF GYRATION	KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA	ROLL=	22102.	PITCH=	256440.	YAW=	256440.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - LANDED CARGO

W= 25000.0	X=	1420.00	Y=	.00	Z=	400.00
RAD OF GYRATION	KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA	ROLL=	22102.	PITCH=	256440.	YAW=	256440.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION W/ABES UNITS - INCH

A RESID LB	307.	742.	-50.	228.	1.	1.	1.	0	387.	926.
A RESID RB	307.	742.	50.	228.	1.	1.	1.	0	387.	926.
A RESID LH	57.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
A RESID RH	58.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
STAGE PNEU	8.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
BAMS LB	396.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
BAMS LB	397.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
BAMS H	551.	870.	0.	360.	1.	1.	1.	0	628.	1070.
BAMS HE	86.	956.	0.	365.	1.	1.	1.	0	936.	972.
ECS RESID	621.	1000.	0.	440.	100.	200.	200.	0	800.	1400.
HYD FLD	1087.	1900.	0.	200.	200.	200.	25.	0	1600.	2000.
GEAR BIL N	42.	388.	0.	140.	1.	1.	1.	0	384.	392.
GEAR BIL LM	42.	1600.	-210.	110.	1.	1.	1.	0	1595.	1605.
GEAR BIL RM	42.	1600.	210.	110.	1.	1.	1.	0	1595.	1605.
CR RESID L	90.	1452.	-95.	370.	1.	1.	1.	0	1378.	1524.
CR RESID R	90.	1452.	95.	370.	1.	1.	1.	0	1378.	1524.
CR ENG BIL	6.	1490.	-140.	8.	1.	1.	1.	0	1420.	1590.
CR ENG BIL	6.	1675.	-330.	127.	1.	1.	1.	0	1605.	1775.
CR ENG BIL	6.	1490.	140.	86.	1.	1.	1.	0	1420.	1590.
CR ENG BIL	6.	1675.	330.	127.	1.	1.	1.	0	1605.	1775.

RESID FLUIDS

W=	4205.0	X=	1388.77	Y=	0.04	Z=	281.79
RAD OF GYRATION	KROLL=	153.94	KPIT=	527.80	KYAW=	513.56	
MOM OF INERTIA	ROLL=	21508.	PITCH=	252834.	YAW=	239379.	
PROD OF INERTIA	ROL-PIT=	9.	PIT-YAW=	13.	YAW-ROL=	-19458.	

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

25K 55 DEG MISSION UNITS • INCH

SUB-TOTAL - RESID FLUIDS

W=	4205.0	X=	1388.77	Y=	.04	Z= 281.79
RAD OF GYRATION		KROL=	153.94	KPIT=	527.80	KYAW= 513.56
MOM OF INERTIA		ROLL=	21508.	PITCH=	252834.	YAW= 239379.
PROD OF INERTIA		ROL-PIT=	9.	PIT-YAW=	13.	YAW-ROL= -19458.

ACCUM. TOTAL • INERT WEIGHT

W=	265026.7	X=	1478.28	Y=	-0.15	Z= 273.02
RAD OF GYRATION		KROL=	195.20	KPIT=	462.85	KYAW= 473.55
MOM OF INERTIA		ROLL=	2179553.	PITCH=	12254913.	YAW= 12828100.
PROD OF INERTIA		ROL-PIT=	-11036.	PIT-YAW=	1580.	YAW-ROL= 42790.

C.G. AS % L • 67.7 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
25K 55 DEG MISSION				UNITS • INCH						
CR RESER L	1140.	1452.	-95.	370.	1.	1.	1.	0	1378.	1524.
CR RESER R	1140.	1452.	95.	370.	1.	1.	1.	0	1378.	1524.
ENT ACS LB	647.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS RB	648.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS H	367.	870.	0.	360.	1.	1.	1.	0	628.	1070.
AUX RESER BL	1713.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
AUX RESER BR	1712.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
AUX RESER H	693.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	19.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
ECS RES	102.	850.	0.	445.	1.	1.	1.	0	840.	860.
HYD APU LB	33.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RB	33.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	82.	870.	0.	360.	1.	1.	1.	0	628.	1070.

RESERVE FLDS

W= 8329.0	X=	1631.73	Y=	0.00	Z=	310.66
RAD OF GYRATION	KROL=	98.13	KPIT=	380.33	KYAW=	386.17
MOM OF INERTIA	ROLL=	17310.	PITCH=	260044.	YAW=	268095.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-29356.

SUB-TOTAL - RESERVE FLDS

W= 8329.0	X=	1631.73	Y=	.00	Z=	310.66
RAD OF GYRATION	KROL=	98.13	KPIT=	380.33	KYAW=	386.17
MOM OF INERTIA	ROLL=	17310.	PITCH=	260044.	YAW=	268095.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-29356.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

25K 55 DEG MISSION UNITS = INCH

ACCUM. TOTAL = LANDING WT

W= 273355.7	X= 1482.95	Y= -0.15	Z= 274.16
RAD OF GYRATION	KROL= 193.07	KPIT= 461.36	KYAW= 471.87
MOM OF INERTIA	ROLL= 2199332.	PITCH= 12558563.	YAW= 13137326.
PROD OF INERTIA	ROL-PIT= -10995.	PIT-YAW= 1590.	YAW-ROL= 23495.

C.G. AS % L = 67.9 %

MAIN STRUT R	1065.	1681.	198.	162.	17.	39.	39.	0	1614.	1747.
MAIN STRUT L	1065.	1681.	-198.	162.	17.	39.	39.	0	1614.	1747.
MAIN AXLE RH	127.	1747.	198.	173.	9.	16.	16.	0	1719.	1775.
MAIN AXLE LH	127.	1747.	-198.	173.	9.	16.	16.	0	1719.	1775.
ATT FTG RH	137.	1614.	198.	151.	25.	5.	25.	0	1600.	1628.
ATT FTG LH	137.	1614.	-198.	151.	25.	5.	25.	0	1600.	1628.
WHL INBD RH	182.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
WHL INBD LH	182.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
WHL OUTBD RH	182.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
WHL OUTBD LH	182.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
BKE INBD RH	303.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
BKE INBD LH	303.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
BKE OUTBD RH	303.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
BRK OUTBD LH	303.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
TIRE INBD RH	263.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
TIRE INBD LH	263.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS = INCH

TIRE OUTBD R	263.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
TIRE OUTBD L	263.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
AIR INBD RH	20.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
AIR INBD LH	20.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
AIR OUTBD RH	20.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
AIR OUTBD LH	20.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
CONTROL RH	422.	1681.	198.	173.	17.	39.	39.	0	1614.	1747.
CONTROL LH	422.	1681.	-198.	173.	17.	39.	39.	0	1614.	1747.
ANTI SKID RH	25.	1747.	198.	162.	20.	20.	20.	0	1721.	1774.
ANTI SKID LH	25.	1747.	-198.	162.	20.	20.	20.	0	1721.	1774.

MAIN GEAR

W= 6624.0	X=	1711.87	Y=	0.00	Z=	168.47
RAD OF GYRATION	KROL=	199.32	KPIT=	48.66	KYAW=	204.19
MOM OF INERTIA	ROLL=	56799.	PITCH=	3385.	YAW=	59611.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	279.

MAIN GEAR EX	-6624.	1611.	0.	53.	203.	43.	199.	0	1580.	1710.

EXT VS RET

W= -6624.0	X=	1611.00	Y=	0.00	Z=	53.00
RAD OF GYRATION	KROL=	203.00	KPIT=	43.00	KYAW=	199.00
MOM OF INERTIA	ROLL=	-58918.	PITCH=	-2644.	YAW=	-56619.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
25K 55 DEG MISSION		UNITS • INCH								
NG STRUT	480.	329.	0.	193.	50.	39.	39.	0	257.	390.
ATT FTG NG	53.	390.	0.	178.	50.	3.	50.	0	380.	400.
NG AXLE	30.	258.	0.	208.	50.	1.	50.	0	255.	261.
WHL RH NG	29.	258.	9.	208.	11.	10.	11.	0	240.	275.
WHL LH NG	29.	258.	-9.	208.	11.	10.	11.	0	240.	275.
TIRE RH NG	56.	258.	9.	208.	11.	10.	11.	0	240.	275.
TIRE LH NG	56.	258.	-9.	208.	11.	10.	11.	0	240.	275.
AIR RH NG	3.	258.	9.	208.	11.	10.	11.	0	240.	275.
AIR LHNG	3.	258.	-9.	208.	11.	10.	11.	0	240.	275.
CONTROLS NG	237.	329.	0.	193.	50.	39.	39.	0	257.	390.
NOSE GEAR										
W= 976.0	X=	317.33	Y=	0.00	Z=	195.35				
RAD OF GYRATION	KROL=	46.26	KPIT=	48.17	KYAW=	49.96				
MOM OF INERTIA	ROLL=	451.	PITCH=	489.	YAW=	526.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-52.				
NOSE GEAR EX	-976.	379.	0.	112.	54.	44.	37.	0	350.	390.
NG EXT VS RE										
W= -976.0	X=	379.00	Y=	0.00	Z=	112.00				
RAD OF GYRATION	KROL=	54.00	KPIT=	44.00	KYAW=	37.00				
MOM OF INERTIA	ROLL=	-614.	PITCH=	-408.	YAW=	-288.				
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.				

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS = INCH

GEAR SIL N	-42.	388.	0.	140.	1.	1.	1.	0	384.	392.
GEAR SIL LM	-42.	1600.	-210.	110.	1.	1.	1.	0	1595.	1605.
GEAR SIL RM	-42.	1600.	210.	110.	1.	1.	1.	0	1595.	1605.
GEAR SIL N	42.	1675.	-210.	175.	1.	1.	1.	0	640.	720.
GEAR SIL LM	42.	1675.	210.	175.	1.	1.	1.	0	640.	720.
GEAR SIL N	42.	340.	0.	195.	1.	1.	1.	0	300.	380.
HYD APU LB	8.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RB	8.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	21.	870.	0.	360.	1.	1.	1.	0	628.	1070.
CR JP-4 L	570.	1452.	-95.	370.	1.	1.	1.	0	1378.	1524.
CR JP-4 R	570.	1452.	95.	370.	1.	1.	1.	0	1378.	1524.

CRUISE PROP

W= 1177.0	X=	1447.91	Y=	0.00	Z=	368.43
RAD OF GYRATION	KROL=	94.82	KPIT=	95.30	KYAW=	133.38
MOM OF INERTIA	ROLL=	2284.	PITCH=	2307.	YAW=	4520.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-138.

ACCUM. TOTAL = CRUISE PROP

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS = INCH

ACCUM. TOTAL = FLIGHT WT

W= 274532.7	X= 1485.03	Y= -0.15	Z= 277.68			
RAD OF GYRATION	KROL= 190.14	KPIT= 460.90	KYAW= 472.48			
MOM OF INERTIA	ROLL= 2142246.	PITCH= 12587544.	YAW= 13228026.			
PROD OF INERTIA	ROL-PIT= -10977.	PIT-YAW= 1621.	YAW-ROL= 9350.			

C.G. AS % L = 68.0 %

HYD APU LO	142.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RO	142.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	352.	870.	0.	360.	1.	1.	1.	0	628.	1070.
OAMS LOSS H	160.	870.	0.	360.	1.	1.	1.	0	628.	1070.
COLD HE	38.	956.	0.	365.	1.	1.	1.	0	936.	972.
ENT ACS LO	390.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS RO	389.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS H	221.	870.	0.	360.	1.	1.	1.	0	628.	1070.
ENG&NAC OUT	-3338.	1681.	-337.	133.	20.	33.	31.	0	1609.	1766.
ENG&NAC OUT	-3338.	1506.	-142.	84.	20.	33.	31.	0	1434.	1591.
ENG&NAC OUT	-3338.	1681.	337.	133.	20.	33.	31.	0	1609.	1766.
ENG&NAC OUT	-3338.	1506.	142.	84.	20.	33.	31.	0	1434.	1591.

ENGS OUT DOW

W= -11516.0	X= 1611.98	Y= 0.01	Z= 76.92			
RAD OF GYRATION	KROL= 265.24	KPIT= 203.21	KYAW= 205.51			
MOM OF INERTIA	ROLL= -174876.	PITCH= 102640.	YAW= -104980.			
PROD OF INERTIA	ROL-PIT= -6.	PIT-YAW= -4.	YAW-ROL= -25992.			

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
25K 55 DEG MISSION		UNITS = INCH								
ENGINE 8BLH	2665.	1681.	-273.	195.	16.	30.	30.	0	1609.	1766.
IGN WIRE	8.	1663.	-275.	195.	25.	18.	18.	0	1609.	1766.
HEAT XCHNGR	20.	1667.	-250.	214.	2.	3.	3.	0	1609.	1766.
ACCUM	15.	1667.	-250.	206.	4.	6.	6.	0	1609.	1766.
LINE&VALVE	9.	1666.	-265.	195.	25.	18.	18.	0	1609.	1766.
BLEED AIR	10.	1663.	-275.	195.	15.	18.	18.	0	1609.	1766.
INSTR	18.	1681.	-275.	195.	16.	30.	30.	0	1609.	1766.
STARTER	50.	1639.	-247.	199.	5.	14.	14.	0	1609.	1766.
FIRE EXT	21.	1691.	-318.	195.	2.	4.	9.	0	1609.	1766.
FIRE SENS	2.	1678.	-291.	195.	25.	17.	17.	0	1609.	1766.
LINES&MISC	4.	1678.	-291.	195.	25.	17.	17.	0	1609.	1766.
AIR INDUCT	16.	1627.	-275.	195.	26.	14.	14.	0	1609.	1766.
ENG MNTS	110.	1684.	-275.	195.	26.	17.	17.	0	1609.	1766.
NACELLE	213.	1681.	-275.	195.	25.	46.	46.	0	1609.	1766.
PYL8N	179.	1696.	-314.	195.	6.	29.	29.	0	1609.	1766.

ENG & NAC

W= 3337.5	X=	1680.80	Y=	-275.08	Z=	195.22
RAD 8F GYRATION	KR8L=	19.91	KPIT=	31.24	KYAW=	33.00
M8M 8F INERTIA	R8LL=	286.	PITCH=	703.	YAW=	784.
PR8D 8F INERTIA	R8L=PIT=	-40.	PIT=YAW=	4.	YAW=R8L=	-3.

ENGINE IBRH	2665.	1506.	-189.	190.	16.	30.	30.	0	1434.	1591.
IGN WIRE	8.	1488.	-200.	202.	25.	18.	18.	0	1434.	1591.
HEAT XCHNGR	20.	1492.	-226.	227.	2.	3.	3.	0	1434.	1591.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS • INCH

ACCUM	15.	1492.	-226.	227.	4.	6.	6.	0	1434.	1591.
LINE & VALV	9.	1491.	-211.	212.	25.	18.	18.	0	1434.	1591.
BLEED AIR	10.	1488.	-201.	202.	25.	18.	18.	0	1434.	1591.
INSTR	18.	1506.	-201.	202.	16.	30.	30.	0	1434.	1591.
STARTER	50.	1464.	-230.	231.	5.	14.	14.	0	1434.	1591.
FIRE EXT	21.	1516.	-158.	159.	2.	4.	9.	0	1434.	1591.
FIRE SENS	2.	1503.	-185.	186.	25.	17.	17.	0	1434.	1591.
LINES&MISC	4.	1503.	-185.	186.	25.	17.	17.	0	1434.	1591.
AIR INDUCT	16.	1452.	-201.	202.	26.	14.	14.	0	1434.	1591.
ENG MTS	110.	1509.	-201.	202.	26.	17.	17.	0	1434.	1591.
NACELLE	213.	1506.	-201.	202.	25.	46.	46.	0	1434.	1591.
PYLON	179.	1521.	-162.	163.	6.	29.	29.	0	1434.	1591.

ENG & NAC

W= 3337.5	X=	1505.80	Y=	-189.75	Z=	190.76
RAD OF GYRATION	KROLL=	21.96	KPIT=	32.80	KYAW=	32.80
MOM OF INERTIA	ROLL=	347.	PITCH=	775.	YAW=	775.
PROD OF INERTIA	ROL-PIT=	42.	PIT-YAW=	-73.	YAW-ROL=	-42.

ENGINE BRH	2665.	1681.	273.	195.	16.	30.	30.	0	1609.	1766.
IGN WIRE	8.	1663.	275.	195.	25.	18.	18.	0	1609.	1766.
HEAT XCHNGR	20.	1667.	250.	214.	2.	3.	3.	0	1609.	1766.
ACCUM	15.	1667.	250.	206.	4.	6.	6.	0	1609.	1766.
LINE&VALVE	9.	1666.	265.	195.	25.	18.	18.	0	1609.	1766.
BLEED AIR	10.	1663.	275.	195.	15.	18.	18.	0	1609.	1766.
INSTR	18.	1681.	275.	195.	16.	30.	30.	0	1609.	1766.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

STARTER	50.	1639.	247.	199.	5.	14.	14.	0	1609.	1766.
FIRE EXT	21.	1691.	318.	195.	2.	4.	9.	0	1609.	1766.
FIRE SENS	2.	1678.	291.	195.	25.	17.	17.	0	1609.	1766.
LINES&MISC	4.	1678.	291.	195.	25.	17.	17.	0	1609.	1766.
AIR INDUCT	16.	1627.	275.	195.	26.	14.	14.	0	1609.	1766.
ENG MNTS	110.	1684.	275.	195.	26.	17.	17.	0	1609.	1766.
NACELLE	213.	1681.	275.	195.	25.	46.	46.	0	1609.	1766.
PYLON	179.	1696.	314.	195.	6.	29.	29.	0	1609.	1766.

ENG & NAC

W= 3337.5	X=	1680.80	Y=	275.08	Z=	195.22
RAD OF GYRATION	KROL=	19.91	KPIT=	31.24	KYAW=	33.00
MOM OF INERTIA	ROLL=	286.	PITCH=	703.	YAW=	784.
PROD OF INERTIA	ROL=PIT=	40.	PIT=YAW=	-4.	YAW=ROL=	-3.

ENGINE IBLH	2665.	1506.	189.	190.	16.	30.	30.	0	1434.	1591.
IGN WIRE	8.	1488.	200.	202.	25.	18.	18.	0	1434.	1591.
HEAT XCHNGR	20.	1492.	226.	227.	2.	3.	3.	0	1434.	1591.
ACCUM	15.	1492.	226.	227.	4.	6.	6.	0	1434.	1591.
LINE & VALV	9.	1491.	211.	212.	25.	18.	18.	0	1434.	1591.
BLEED AIR	10.	1488.	201.	202.	25.	18.	18.	0	1434.	1591.
INSTR	18.	1506.	201.	202.	16.	30.	30.	0	1434.	1591.
STARTER	50.	1464.	230.	231.	5.	14.	14.	0	1434.	1591.
FIRE EXT	21.	1516.	158.	159.	2.	4.	9.	0	1434.	1591.
FIRE SENS	2.	1503.	185.	186.	25.	17.	17.	0	1434.	1591.
LINES&MISC	4.	1503.	185.	186.	25.	17.	17.	0	1434.	1591.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	
25K 55 DEG MISSION UNITS = INCH										
AIR INDUCT	16.	1452.	201.	202.	26.	14.	14.	0	1434.	1591.
ENG MTS	110.	1509.	201.	202.	26.	17.	17.	0	1434.	1591.
NACELLE	213.	1506.	201.	202.	25.	46.	46.	0	1434.	1591.
PYLON	179.	1521.	162.	163.	6.	29.	29.	0	1434.	1591.
ENG & NAC										
W= 3337.5	X=	1505.80	Y=	189.75	Z=	190.76				
RAD OF GYRATION	KROLL=	21.96	KPIT=	32.80	KYAW=	32.80				
MOM OF INERTIA	ROLL=	347.	PITCH=	775.	YAW=	775.				
PROD OF INERTIA	ROL-PIT=	-42.	PIT-YAW=	73.	YAW-ROL=	-42.				
CR ENG OIL	-6.	1490.	-140.	8.	1.	1.	1.	0	1420.	1590.
CR ENG OIL	-6.	1675.	-330.	127.	1.	1.	1.	0	1605.	1775.
CR ENG OIL	-6.	1490.	140.	86.	1.	1.	1.	0	1420.	1590.
CR ENG OIL	-6.	1675.	330.	127.	1.	1.	1.	0	1605.	1775.
CR ENG OIL	6.	1490.	-200.	196.	1.	1.	1.	0	1420.	1590.
CR ENG OIL	6.	1675.	-260.	205.	1.	1.	1.	0	1605.	1775.
CR ENG OIL	6.	1490.	200.	196.	1.	1.	1.	0	1420.	1590.
CR ENG OIL	6.	1675.	260.	205.	1.	1.	1.	0	1605.	1775.
ACCUM. TOTAL = ENTRY ACS										

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS • INCH

ACCUM. TOTAL • ENTRY WT

W= 276366.4	X= 1484.97	Y= -0.15	Z= 281.96
RAD OF GYRATION	KROLL= 185.32	KPIT= 460.11	KYAW= 472.24
MOM OF INERTIA	ROLL= 2048718.	PITCH= 12628373.	YAW= 13302990.
PROD OF INERTIA	ROL•PIT= -10986.	PIT•YAW= 1644.	YAW•ROL= 20822.

C.G. AS % L = 68.0 %

DEORBIT OL	3929.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
DEORBIT OR	3929.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
DEORBIT H	1571.	870.	0.	360.	1.	1.	1.	0	628.	1070.

RETRO PROP

W= 9429.0	X= 1740.89	Y= 0.00	Z= 283.33
RAD OF GYRATION	KROL= 88.19	KPIT= 390.91	KYAW= 397.79
MOM OF INERTIA	ROLL= 15829.	PITCH= 310988.	YAW= 322031.
PROD OF INERTIA	ROL•PIT= 0.	PIT•YAW= 0.	YAW•ROL= -27168.

ACCUM. TOTAL • RETRO PROP

ACCUM. TOTAL • PRE RETRO WT

W= 285795.4	X= 1493.41	Y= -0.14	Z= 282.01
RAD OF GYRATION	KROL= 182.94	KPIT= 460.27	KYAW= 472.19
MOM OF INERTIA	ROLL= 2064544.	PITCH= 13068354.	YAW= 13754012.
PROD OF INERTIA	ROL•PIT= -10912.	PIT•YAW= 1645.	YAW•ROL= -5672.

C.G. AS % L = 68.5 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
25K 55 DEG MISSION				UNITS = INCH						
ASCENT LGBX	31.	742.	-50.	228.	1.	1.	1.	0	387.	926.
ASCENT RGBX	30.	742.	50.	228.	1.	1.	1.	0	387.	926.
ASCENT LGH	17.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
ASCENT RGH	18.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
MANEU BL	1698.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
MANEU BR	1699.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
MANEU H	962.	870.	0.	360.	1.	1.	1.	0	628.	1070.
ECS N	67.	850.	0.	445.	1.	1.	1.	0	840.	860.
ECS BL	11.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ECS BR	12.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ECS H	234.	870.	0.	360.	1.	1.	1.	0	628.	1070.
EPS BL	284.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
EPS BR	285.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
EPS H	71.	870.	0.	360.	1.	1.	1.	0	628.	1070.
ACS BL	259.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ACS BR	258.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ACS H	146.	870.	0.	360.	1.	1.	1.	0	500.	1080.
COLD HE	25.	956.	0.	365.	1.	1.	1.	0	936.	972.
BAMS LOSS LB	13.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
BAMS LOSS RB	13.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
BAMS LOSS H	1268.	870.	0.	360.	1.	1.	1.	0	628.	1070.

ON ORB LOSS

W= 7401.0	X= 1511.14	Y= 0.03	Z= 302.74		
RAD OF GYRATION	KROL= 84.17	KPIT= 510.88	KYAW= 513.51		
MOM OF INERTIA	ROLL= 11317.	PITCH= 416935.	YAW= 421236.		
PROD OF INERTIA	ROL*PIT= 21.	PIT*YAW= -1.	YAW*ROL= .35656.		

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

ACCUM. TOTAL = ON ORB LOSS

CARGO	=25000.	1420.	0.	400.	64.	218.	218.	0	1120.	1840.

LANDED CARGO

W=	=25000.0	X=	1420.00	Y=	0.00	Z=	400.00
RAD OF GYRATION		KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA		ROLL=	=22102.	PITCH=	=256440.	YAW=	=256440.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ACCUM. TOTAL = LANDED CARGO

CARGO	25000.	1420.	0.	400.	64.	218.	218.	0	1120.	1840.

ASCENT CARGO

W=	25000.0	X=	1420.00	Y=	0.00	Z=	400.00
RAD OF GYRATION		KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA		ROLL=	22102.	PITCH=	256440.	YAW=	256440.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ACCUM. TOTAL = ASCENT CARGO

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

25K 55 DEG MISSION UNITS = INCH

ACCUM. TOTAL = ON ORBIT WT

W= 293196.4	X= 1493.86	Y= -0.14	Z= 282.53		
RAD OF GYRATION	KROL= 181.14	KPIT= 461.64	KYAW= 473.29		
MOM OF INERTIA	ROLL= 2076529.	PITCH= 13486678.	YAW= 14175966.		
PROD OF INERTIA	ROL-PIT= -10886.	PIT-YAW= 1649.	YAW-ROL= -40753.		

C.G. AS % L = 68.5 %

MANEU OL	5637.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
MANEU OR	5637.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
MANEU H	2255.	870.	0.	360.	1.	1.	1.	0	628.	1070.

MANEUV PROP

W= 13529.0	X= 1740.82	Y= 0.00	Z= 283.33		
RAD OF GYRATION	KROL= 88.19	KPIT= 390.98	KYAW= 397.85		
MOM OF INERTIA	ROLL= 22711.	PITCH= 446374.	YAW= 462215.		
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -38991.		

ACCUM. TOTAL = MANEUV PROP

RESER OL	2695.	742.	-50.	228.	1.	1.	1.	0	387.	926.
RESER OR	2696.	742.	50.	228.	1.	1.	1.	0	387.	926.
RESER HL	450.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
RESER HR	449.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
DUMPED OL	1894.	742.	-30.	228.	1.	1.	1.	0	387.	826.
DUMPED OR	1894.	742.	30.	228.	1.	1.	1.	0	387.	926.
DUMPED HL	172.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

DUMPED HR	173.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
BAMS LOSS H	35.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
SHUTDN LB	88.	742.	-50.	228.	1.	1.	1.	0	387.	926.

DUMPED PROP

W= 10423.0	X=	812.30	Y=	0.00	Z=	228.00
RAD OF GYRATION	KROLL=	45.28	KPIT=	190.96	KYAW=	196.25
MOM OF INERTIA	ROLL=	4614.	PITCH=	82034.	YAW=	86646.
PROD OF INERTIA	ROL-PIT=	-1.	PIT-YAW=	0.	YAW-ROL=	-0.

ACCUM. TOTAL = DUMPED PROP

ACCUM. TOTAL = INJECTION WT

W= 317148.4	X=	1481.99	Y=	-0.13	Z=	280.77
RAD OF GYRATION	KROLL=	175.58	KPIT=	471.76	KYAW=	482.53
MOM OF INERTIA	ROLL=	2110335.	PITCH=	15235150.	YAW=	15938413.
PROD OF INERTIA	ROL-PIT=	-10997.	PIT-YAW=	1633.	YAW-ROL=	3027.

C.G. AS % L = 67.9 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

SHUTDN R8	88.	742.	50.	228.	1.	1.	1.	0	387.	926.
SHUTDN LH	40.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
SHUTDN RH	40.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
MAIN L8	56403.	890.	-60.	228.	1.	1.	1.	0	845.	926.
MAIN R8	56403.	890.	60.	228.	1.	1.	1.	0	845.	926.
MAIN LH	9401.	1637.	-60.	228.	1.	1.	1.	0	1535.	1739.
MAIN RH	9401.	1637.	60.	228.	1.	1.	1.	0	1535.	1739.

ASCENT PR8P

W= 131904.0	X=	996.58	Y=	0.00	Z=	228.04
RAD 8F GYRATI8N	KR8L=	60.03	KPIT=	261.47	KYAW=	268.26
M8M 8F INERTIA	R8LL=	102595.	PITCH=	1946457.	YAW=	2048758.
PR8D 8F INERTIA	R8L-PIT=	0.	PIT-YAW=	0.	YAW-R8L=	-103.

ACCUM. T8TAL = ASCENT PR8P

ACCUM. T8TAL = 75% BURN

W= 449052.4	X=	1339.41	Y=	-0.09	Z=	265.28
RAD 8F GYRATI8N	KR8L=	153.00	KPIT=	476.16	KYAW=	484.21
M8M 8F INERTIA	R8LL=	2268856.	PITCH=	21975328.	YAW=	22724976.
PR8D 8F INERTIA	R8L-PIT=	-12231.	PIT-YAW=	1499.	YAW-R8L=	517662.

C.G. AS % L = 60.4 %

25K 55 DEG MISSION UNITS = INCH

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
HYD APU L8	29.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU R8	30.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	73.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN L8	56404.	797.	-55.	228.	1.	1.	1.	0	742.	845.
MAIN R8	56404.	797.	55.	228.	1.	1.	1.	0	742.	845.
MAIN LH	9400.	1433.	-60.	228.	1.	1.	1.	0	1331.	1535.
MAIN RH	9401.	1433.	60.	228.	1.	1.	1.	0	1331.	1535.

ASCENT PR8P

W= 131746.0	X=	888.34	Y=	0.00	Z=	228.09
RAD 8F GYRATI8N	KR8L=	55.85	KPIT=	223.60	KYAW=	230.42
M8M 8F INERTIA	R8LL=	88703.	PITCH=	1421675.	YAW=	1509755.
PR8D 8F INERTIA	R8L-PIT=	27.	PIT-YAW=	1.	YAW-R8L=	511.

ACCUM. T8TAL = ASCENT PR8P

ACCUM. T8TAL = 50% BURN

W= 580798.4	X=	1237.09	Y=	-0.07	Z=	256.85
RAD 8F GYRATI8N	KR8L=	138.02	KPIT=	471.77	KYAW=	478.54
M8M 8F INERTIA	R8LL=	2387982.	PITCH=	27900720.	YAW=	28708048.
PR8D 8F INERTIA	R8L-PIT=	.13100.	PIT-YAW=	1426.	YAW-R8L=	887038.

C.G. AS % L = 55.1 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN LØ	56404.	685.	-45.	228.	1.	1.	1.	0	613.	742.
MAIN RØ	56404.	685.	45.	228.	1.	1.	1.	0	613.	742.
MAIN LH	9401.	1230.	-60.	228.	1.	1.	1.	0	1128.	1331.
MAIN RH	9401.	1230.	60.	228.	1.	1.	1.	0	1128.	1331.

ASCENT PRØP

W= 131615.0	X=	762.90	Y=	0.00	Z=	228.00
RAD ØF GYRATIØN	KRØL=	47.45	KPIT=	190.82	KYAW=	196.63
MØM ØF INERTIA	RØLL=	63959.	PITCH=	1034448.	YAW=	1098376.
PRØD ØF INERTIA	RØL-PIT=	0.	PIT-YAW=	0.	YAW-RØL=	28.

ACCUM. TØTAL = ASCENT PRØP

ACCUM. TØTAL = 25% BURN

W= 712413.4	X=	1149.48	Y=	-0.06	Z=	251.52
RAD ØF GYRATIØN	KRØL=	126.77	KPIT=	471.35	KYAW=	477.19
MØM ØF INERTIA	RØLL=	2471192.	PITCH=	34162288.	YAW=	35014256.
PRØD ØF INERTIA	RØL-PIT=	-13855.	PIT-YAW=	1380.	YAW-RØL=	1203822.

C.G. AS % L = 50.6 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

25K 55 DEG MISSION UNITS = INCH

STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN LB	56403.	520.	-53.	228.	1.	1.	1.	0	387.	613.
MAIN RB	56404.	520.	53.	228.	1.	1.	1.	0	387.	613.
MAIN LH	9400.	1026.	-60.	228.	1.	1.	1.	0	926.	1128.
MAIN RH	9400.	1026.	60.	228.	1.	1.	1.	0	926.	1128.

ASCENT PROP

W= 131612.0	X=	592.33	Y=	0.00	Z=	228.00
RAD OF GYRATION	KROL=	54.07	KPIT=	177.22	KYAW=	185.28
MOM OF INERTIA	ROLL=	83048.	PITCH=	892211.	YAW=	975225.
PROD OF INERTIA	ROL-PIT=	-1.	PIT-YAW=	0.	YAW-ROL=	32.

ACCUM. TOTAL = ASCENT PROP

ACCUM. TOTAL = IGNITION

W= 844025.4	X=	1062.60	Y=	-0.05	Z=	247.85
RAD OF GYRATION	KROL=	118.72	KPIT=	483.06	KYAW=	488.27
MOM OF INERTIA	ROLL=	2567501.	PITCH=	42510816.	YAW=	43432512.
PROD OF INERTIA	ROL-PIT=	-14610.	PIT-YAW=	1348.	YAW-ROL=	1518018.

C.G. AS % L = 46.1 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES
25K 55 DEG MISSION UNITS = INCH										
MAIN LB	782.	742.	-50.	228.	1.	1.	1.	0	387.	926.
MAIN RB	782.	742.	50.	228.	1.	1.	1.	0	387.	926.
MAIN LH	199.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
MAIN RH	199.	1331.	60.	228.	1.	1.	1.	0	926.	1739.

STARTUP

W= 1962.0	X=	861.48	Y=	0.00	Z=	228.00
RAD OF GYRATION	KROL=	52.19	KPIT=	236.85	KYAW=	242.53
MOM OF INERTIA	ROLL=	1154.	PITCH=	23757.	YAW=	24910.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ACCUM. TOTAL = STARTUP

ACCUM. TOTAL = LAUNCH WT

W= 845987.4	X=	1062.14	Y=	-0.05	Z=	247.80
RAD OF GYRATION	KROL=	118.61	KPIT=	482.74	KYAW=	487.94
MOM OF INERTIA	ROLL=	2568820.	PITCH=	42551664.	YAW=	43474368.
PROD OF INERTIA	ROL-PIT=	-14614.	PIT-YAW=	1348.	YAW-ROL=	1519701.

C.G. AS % L = 46.0 %

Appendix C

This appendix contains the detail build-up of component weight, center-of-gravity, moment of inertia and product of inertia for the 40K Polar Mission. To reduce the volume of this report only the differences from the easterly mission have been shown in this appendix. If data is required on a subsystem not in this appendix, then see Appendix A.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
40K POLAR MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	31587.	1738.	0.	194.	549.	423.	962.
					0.	0.	4.
TAILS	5104.	2054.	0.	632.	2.	11.	11.
					0.	0.	2.
BODY	55500.	1292.	0.	291.	191.	2605.	2551.
					0.	0.	82.
THERMAL PROT	32847.	1353.	-0.	191.	388.	2734.	3095.
					-0.	-0.	-6.
LANDING/DOCK	10551.	1438.	-0.	129.	102.	432.	452.
					-0.	-0.	-36.
PROP-ASCENT	26637.	1863.	4.	320.	42.	416.	395.
					-3.	-1.	3.
PROP-CRUISE	574.	1542.	25.	288.	3.	2.	4.
					0.	-0.	-0.
PROP-AUXIL	11877.	1291.	6.	320.	31.	677.	691.
					-0.	1.	-28.
PRIME POWER	2272.	1015.	-31.	258.	1.	264.	265.
					-12.	-0.	9.
ELEC DIST	1303.	832.	-16.	235.	0.	48.	48.
					-2.	-0.	2.
HYDRA DIST	2760.	1705.	-52.	262.	5.	42.	45.
					-2.	-0.	3.
SURF CONTROL	4901.	1944.	0.	308.	92.	33.	71.
					0.	0.	7.
AVIONICS	4588.	1030.	1.	384.	12.	101.	99.
					1.	-0.	-5.
ENVIR CONTRL	7849.	1124.	0.	363.	41.	250.	245.
					-0.	-0.	-11.
PERSNL PROV	430.	962.	7.	451.	0.	0.	0.
					-0.	-0.	-0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	23086.	1479.	0.	269.	0.	0.	0.
					0.	0.	0.
DRY WEIGHT	221865.	1479.	-0.	269.	1753.	11431.	11985.
					-11.	2.	167.
PERSONNEL	626.	951.	-1.	455.	0.	0.	0.
					-0.	-0.	-0.
LANDED CARGO	40000.	1420.	0.	400.	35.	410.	410.
					0.	0.	0.
RESID FLUIDS	4001.	1385.	0.	279.	20.	252.	238.
					0.	-0.	-20.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
40K POLAR MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y (INCH)	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
INERT WEIGHT	266492.	1468.	-0.	290.	1938.	12291.	12703.
					-11.	2.	80.
RESERVE FLDS	10013.	1789.	0.	280.	17.	253.	266.
					0.	-0.	-24.
LANDING WT	276505.	1479.	-0.	289.	1955.	12759.	13183.
					-11.	2.	49.
CRUISE PROP	37.	17869.	0.	23401.	-4332.	-6389.	-2056.
					0.	0.	-3039.
FLIGHT WT	276542.	1482.	-0.	292.	1888.	12780.	13272.
					-11.	2.	35.
ENTRY ACS	1834.	1477.	-0.	307.	3.	105.	106.
					-0.	0.	-9.
ENTRY WT	278376.	1482.	-0.	292.	1891.	12886.	13379.
					-11.	2.	25.
RETRO PROP	4901.	1741.	0.	283.	8.	162.	167.
					0.	0.	-14.
PRE RETRO WT	283277.	1486.	-0.	292.	1900.	13118.	13616.
					-11.	2.	9.
ON ORB LOSS	6735.	1506.	0.	303.	10.	381.	385.
					0.	-0.	-33.
LANDED CARGO	-40000.	1420.	0.	400.	-35.	-410.	-410.
					0.	0.	0.
ASCENT CARGO	40000.	1420.	0.	400.	35.	410.	410.
					0.	0.	0.
ON ORBIT WT	290012.	1487.	-0.	292.	1910.	13500.	14002.
					-11.	2.	-23.
MANEUV PROP	1765.	1741.	-0.	283.	3.	58.	60.
					-0.	0.	-5.
DUMPED PROP	10298.	812.	0.	228.	5.	81.	85.
					0.	0.	0.
INJECTION WT	302075.	1465.	-0.	290.	1926.	14653.	15153.
					-11.	2.	64.

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
40K POLAR MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ASCENT PROP	144181.	1054.	0.	233.	132.	3587.	3693.
					0.	-0.	55.
75% BURN	446256.	1332.	-0.	272.	2127.	21862.	22399.
					-12.	2.	613.
ASCENT PROP	135151.	910.	0.	229.	97.	2052.	2142.
					0.	0.	24.
50% BURN	581407.	1234.	-0.	262.	2263.	27955.	28542.
					-13.	1.	1038.
ASCENT PROP	135019.	787.	0.	229.	72.	1827.	1893.
					0.	0.	29.
25% BURN	716426.	1150.	-0.	256.	2360.	34528.	35155.
					-14.	1.	1411.
ASCENT PROP	135019.	621.	0.	229.	91.	1943.	2027.
					0.	0.	35.
IGNITION	851445.	1066.	-0.	252.	2468.	43347.	44042.
					-14.	1.	1789.
STARTUP	1962.	861.	0.	228.	1.	24.	25.
					0.	0.	0.
LAUNCH WT	853407.	1066.	-0.	252.	2470.	43388.	44084.
					-14.	1.	1791.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

GRWTH/UNCER 23086. 1479. 0. 269. 0. 0. 0. 0 177. 2100.

GRWTH/UNCER

W= 23086.0	X=	1479.00	Y=	0.00	Z=	269.00
RAD OF GYRATION	KROL=	0.00	KPIT=	0.94	KYAW=	0.94
MOM OF INERTIA	ROLL=	0.	PITCH=	4.	YAW=	4.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	1.

SUB-TOTAL - GROWTH/UNCER

W= 23086.0	X=	1479.00	Y=	.00	Z=	269.00
RAD OF GYRATION	KROL=	.00	KPIT=	.94	KYAW=	.94
MOM OF INERTIA	ROLL=	0.	PITCH=	4.	YAW=	4.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	1.

ACCUM. TOTAL = DRY WEIGHT

W= 221865.1	X=	1479.44	Y=	-0.17	Z=	269.37
RAD OF GYRATION	KROL=	191.34	KPIT=	488.67	KYAW=	500.38
MOM OF INERTIA	ROLL=	1753241.	PITCH=	11435508.	YAW=	11989984.
PROD OF INERTIA	ROL-PIT=	-11034.	PIT-YAW=	1586.	YAW-ROL=	167466.

C.G. AS % L = 67.7 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

CMD PILOT	196.	930.	-21.	458.	15.	18.	8.	0	930.	936.
PILOT	196.	930.	21.	458.	15.	18.	8.	0	930.	936.
CBN WEAR GAR	1.	930.	-21.	458.	14.	16.	8.	0	930.	936.
CBN WEAR GAR	1.	930.	21.	458.	14.	16.	8.	0	930.	936.
HELMET	6.	936.	-21.	483.	3.	3.	3.	0	930.	936.
HELMET	6.	936.	21.	483.	3.	3.	3.	0	930.	936.
PRESS SUIT	13.	930.	-21.	458.	14.	16.	8.	0	930.	936.
PRESS SUIT	13.	930.	21.	458.	14.	16.	8.	0	930.	936.
HEADSET	1.	936.	-21.	483.	3.	3.	3.	0	930.	936.
HEADSET	1.	936.	21.	483.	3.	3.	3.	0	930.	936.

CREW

W= 433.0	X=	930.18	Y=	0.00	Z=	458.73
RAD OF GYRATION	KROLL=	25.99	KPIT=	18.07	KYAW=	22.40
MOM OF INERTIA	ROLL=	63.	PITCH=	31.	YAW=	47.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

PERS EQ-FWA	2.	952.	58.	446.	10.	9.	7.	0	946.	958.
PERS EQ-LKR	10.	1034.	-54.	456.	15.	18.	15.	0	1011.	1056.
PROT GAR-LKR	25.	1034.	-54.	456.	15.	18.	15.	0	1011.	1056.
HYG EQ-WMA	16.	959.	-68.	420.	13.	13.	13.	0	951.	967.

PERSONAL GR

W= 53.0	X=	1008.46	Y=	-54.92	Z=	444.63
RAD OF GYRATION	KROLL=	30.24	KPIT=	42.68	KYAW=	43.83
MOM OF INERTIA	ROLL=	10.	PITCH=	21.	YAW=	22.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	1.	YAW-ROL=	6.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

FOOD & PKG	59.	969.	61.	440.	9.	8.	8.	0	960.	978.
REC EQUIP	3.	955.	-57.	447.	10.	10.	10.	0	945.	965.
MEDICAL EQ	8.	955.	-57.	447.	10.	10.	10.	0	945.	965.
SURVIVAL KIT	45.	1065.	-54.	459.	15.	18.	9.	0	1056.	1074.

LIFE SUPT

W= 115.0	X=	1005.03	Y=	4.71	Z=		448.08
RAD OF GYRATION	KROL=	59.65	KPIT=	50.61	KYAW=		75.67
MOM OF INERTIA	ROLL=	88.	PITCH=	64.	YAW=		142.
PROD OF INERTIA	ROL-PIT=	-52.	PIT-YAW=	-12.	YAW-ROL=		10.

ACCESS	25.	952.	58.	446.	10.	9.	7.	0	946.	958.

ACCESS

W= 25.0	X=	952.00	Y=	58.00	Z=		446.00
RAD OF GYRATION	KROL=	10.00	KPIT=	9.00	KYAW=		7.00
MOM OF INERTIA	ROLL=	1.	PITCH=	0.	YAW=		0.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=		0.

SUB-TOTAL - PERSONNEL

W= 626.0	X=	951.43	Y=	-1.47	Z=		455.07
RAD OF GYRATION	KROL=	40.31	KPIT=	44.72	KYAW=		55.41
MOM OF INERTIA	ROLL=	220.	PITCH=	270.	YAW=		415.
PROD OF INERTIA	ROL-PIT=	-82.	PIT-YAW=	-8.	YAW-ROL=		-6.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

40K POLAR MISSION UNITS - INCH

CARGO 40000. 1420. 0. 400. 64. 218. 218. 0 1120. 1840.

LANDED CARGO

W= 40000.0	X=	1420.00	Y=	0.00	Z=	400.00
RAD OF GYRATION	KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA	ROLL=	35363.	PITCH=	410304.	YAW=	410304.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

SUB-TOTAL - LANDED CARGO

W= 40000.0	X=	1420.00	Y=	.00	Z=	400.00
RAD OF GYRATION	KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA	ROLL=	35363.	PITCH=	410304.	YAW=	410304.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	
40K POLAR MISSION				UNITS = INCH						
A RESID LO	307.	742.	-50.	228.	1.	1.	1.	0	387.	926.
A RESID RO	307.	742.	50.	228.	1.	1.	1.	0	387.	926.
A RESID LH	57.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
A RESID RH	58.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
STAGE PNEU	8.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
OAMS LO	396.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
OAMS LO	397.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
OAMS H	551.	870.	0.	360.	1.	1.	1.	0	628.	1070.
OAMS HE	86.	956.	0.	365.	1.	1.	1.	0	936.	972.
ECS RESID	621.	1000.	0.	440.	100.	200.	200.	0	800.	1400.
HYD FLD	1087.	1900.	0.	200.	200.	200.	25.	0	1600.	2000.
GEAR OIL N	42.	388.	0.	140.	1.	1.	1.	0	384.	392.
GEAR OIL LM	42.	1600.	-210.	110.	1.	1.	1.	0	1595.	1605.
GEAR OIL RM	42.	1600.	210.	110.	1.	1.	1.	0	1595.	1605.

RESID FLUIDS

M=	4001.0	X=	1384.76	Y=	0.04	Z=	278.99
RAD OF GYRATION	KROL=		153.35	KPIT=	540.10	KYAW=	525.29
MOM OF INERTIA	ROLL=		20307.	PITCH=	251910.	YAW=	238289.
PROD OF INERTIA	ROL-PIT=		9.	PIT-YAW=	-1.	YAW-ROL=	-19508.

SUB-TOTAL - RESID FLUIDS

M=	4001.0	X=	1384.76	Y=	.04	Z=	278.99
RAD OF GYRATION	KROL=		153.35	KPIT=	540.10	KYAW=	525.29
MOM OF INERTIA	ROLL=		20307.	PITCH=	251910.	YAW=	238289.
PROD OF INERTIA	ROL-PIT=		9.	PIT-YAW=	-1.	YAW-ROL=	-19508.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

40K POLAR MISSION UNITS - INCH

ACCUM. TOTAL - INERT WEIGHT

W= 266491.9	X= 1467.86	Y= -0.15	Z= 289.56
RAD OF GYRATION	KROL= 183.54	KPIT= 462.34	KYAW= 470.03
MOM OF INERTIA	ROLL= 1937753.	PITCH= 12295191.	YAW= 12707574.
PROD OF INERTIA	ROL-PIT= -11101.	PIT-YAW= 1709.	YAW-ROL= 80317.

C.G. AS % L = 67.1 %

ENT ACS LO	647.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS RO	648.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS H	367.	870.	0.	360.	1.	1.	1.	0	628.	1070.
AUX RESER OL	3714.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
AUX RESER OR	3714.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
AUX RESER H	654.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	19.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
ECS RES	102.	850.	0.	445.	1.	1.	1.	0	840.	860.
HYD APU LO	33.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RO	33.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	82.	870.	0.	360.	1.	1.	1.	0	628.	1070.

RESERVE FLDS

W= 10013.0	X= 1788.86	Y= 0.01	Z= 279.90
RAD OF GYRATION	KROL= 89.95	KPIT= 342.18	KYAW= 350.65
MOM OF INERTIA	ROLL= 17487.	PITCH= 253056.	YAW= 265735.
PROD OF INERTIA	ROL-PIT= 2.	PIT-YAW= -0.	YAW-ROL= -23784.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS - INCH

SUB-TOTAL - RESERVE FLDS

W=	10013.0	X=	1788.86	Y=	.01	Z= 279.90
RAD OF GYRATION		KROL=	89.95	KPIT=	342.18	KYAW= 350.65
MOM OF INERTIA		ROLL=	17487.	PITCH=	253056.	YAW= 265735.
PROD OF INERTIA		ROL-PIT=	2.	PIT-YAW=	-0.	YAW-ROL= -23784.

ACCUM. TOTAL - LANDING WT

W=	276504.9	X=	1479.48	Y=	-0.14	Z= 289.21
RAD OF GYRATION		KROL=	181.01	KPIT=	462.44	KYAW= 470.08
MOM OF INERTIA		ROLL=	1955435.	PITCH=	12763079.	YAW= 13187943.
PROD OF INERTIA		ROL-PIT=	-10996.	PIT-YAW=	1706.	YAW-ROL= 50074.

C.G. AS % L = 67.7 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

40K POLAR MISSION UNITS • INCH

MAIN STRUT R	1065.	1681.	198.	162.	17.	39.	39.	0	1614.	1747.
MAIN STRUT L	1065.	1681.	-198.	162.	17.	39.	39.	0	1614.	1747.
MAIN AXLE RH	127.	1747.	198.	173.	9.	16.	16.	0	1719.	1775.
MAIN AXLE LH	127.	1747.	-198.	173.	9.	16.	16.	0	1719.	1775.
ATT FTG RH	137.	1614.	198.	151.	25.	5.	25.	0	1600.	1628.
ATT FTG LH	137.	1614.	-198.	151.	25.	5.	25.	0	1600.	1628.
WHL INBD RH	182.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
WHL INBD LH	182.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
WHL BUTBD RH	182.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
WHL BUTBD LH	182.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
BKE INBD RH	303.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
BKE INBD LH	303.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
BKE BUTBD RH	303.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
BRK BUTBD LH	303.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
TIRE INBD RH	263.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
TIRE INBD LH	263.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
TIRE BUTBD R	263.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
TIRE BUTBD L	263.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

40K POLAR MISSION UNITS = INCH

AIR INBD RH	20.	1747.	183.	173.	16.	20.	16.	0	1721.	1774.
AIR INBD LH	20.	1747.	-183.	173.	16.	20.	16.	0	1721.	1774.
AIR BUTBD RH	20.	1747.	214.	173.	16.	20.	16.	0	1721.	1774.
AIR BUTBD LH	20.	1747.	-214.	173.	16.	20.	16.	0	1721.	1774.
CONTROL RH	422.	1681.	198.	173.	17.	39.	39.	0	1614.	1747.
CONTROL LH	422.	1681.	-198.	173.	17.	39.	39.	0	1614.	1747.
ANTI SKID RH	25.	1747.	198.	162.	20.	20.	20.	0	1721.	1774.
ANTI SKID LH	25.	1747.	-198.	162.	20.	20.	20.	0	1721.	1774.

MAIN GEAR

W= 6624.0	X=	1711.87	Y=	0.00	Z=	168.47
RAD OF GYRATION	KROLL=	199.32	KPITCH=	48.66	KYAW=	204.19
MOM OF INERTIA	ROLL=	56799.	PITCH=	3385.	YAW=	59611.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	279.

MAIN GEAR EX	-6624.	1611.	0.	53.	203.	43.	199.	0	1580.	1710.

EXT VS RET

W= -6624.0	X=	1611.00	Y=	0.00	Z=	53.00
RAD OF GYRATION	KROLL=	203.00	KPITCH=	43.00	KYAW=	199.00
MOM OF INERTIA	ROLL=	-58918.	PITCH=	-2644.	YAW=	-56619.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

NG STRUT	480.	329.	0.	193.	50.	39.	39.	0	257.	390.
ATT FTG NG	53.	390.	0.	178.	50.	3.	50.	0	380.	400.
NG AXLE	30.	258.	0.	208.	50.	1.	50.	0	255.	261.
WHL RH NG	29.	258.	9.	208.	11.	10.	11.	0	240.	275.

ITEM	WEIGHT	CENTER OF GRAVITY			RADII OF GYRATION			DIST. DATA		
	(LB)	X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
		(INCHES)			(INCHES)				(INCHES)	

40K POLAR MISSION UNITS • INCH

WHL LH NG	29.	258.	-9.	208.	11.	10.	11.	0	240.	275.
TIRE RH NG	56.	258.	9.	208.	11.	10.	11.	0	240.	275.
TIRE LH NG	56.	258.	-9.	208.	11.	10.	11.	0	240.	275.
AIR RH NG	3.	258.	9.	208.	11.	10.	11.	0	240.	275.
AIR LHNG	3.	258.	-9.	208.	11.	10.	11.	0	240.	275.
CONTROLS NG	237.	329.	0.	193.	50.	39.	39.	0	257.	390.

NOSE GEAR

W= 976.0	X=	317.33	Y=	0.00	Z=	195.35
RAD OF GYRATION	KROLL=	46.26	KPITCH=	48.17	KYAW=	49.96
MOM OF INERTIA	ROLL=	451.	PITCH=	489.	YAW=	526.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-52.

NOSE GEAR EX	-976.	379.	0.	112.	54.	44.	37.	0	350.	390.

NG EXT VS RE

W= -976.0	X=	379.00	Y=	0.00	Z=	112.00
RAD OF GYRATION	KROLL=	54.00	KPITCH=	44.00	KYAW=	37.00
MOM OF INERTIA	ROLL=	-614.	PITCH=	-408.	YAW=	-288.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

GEAR OIL N	-42.	388.	0.	140.	1.	1.	1.	0	384.	392.
GEAR OIL LM	-42.	1600.	-210.	110.	1.	1.	1.	0	1595.	1605.
GEAR OIL RM	-42.	1600.	210.	110.	1.	1.	1.	0	1595.	1605.
GEAR OIL N	42.	1675.	-210.	175.	1.	1.	1.	0	640.	720.
GEAR OIL LM	42.	1675.	210.	175.	1.	1.	1.	0	640.	720.
GEAR OIL N	42.	340.	0.	195.	1.	1.	1.	0	300.	380.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES) X	Y	Z	RADII OF GYRATION (INCHES) ROLL	PITCH	YAW	DIST. DATA DI	BS (INCHES)	ES
40K POLAR MISSION					UNITS = INCH					
HYD APU LO	8.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RO	8.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	21.	870.	0.	360.	1.	1.	1.	0	628.	1070.

CRUISE PROP

W= 37.0	X= 1321.89	Y= 0.00	Z= 320.22		
RAD OF GYRATION	KROL= 74.19	KPIT= 519.71	KYAW= 521.01		
MOM OF INERTIA	ROLL= 44.	PITCH= 2157.	YAW= 2168.		
PROD OF INERTIA	ROL-PIT= 0.	PIT-YAW= 0.	YAW-ROL= -188.		

ACCUM. TOTAL = CRUISE PROP

ACCUM. TOTAL = FLIGHT WT

W= 276541.9	X= 1481.67	Y= -0.14	Z= 292.30		
RAD OF GYRATION	KROL= 177.87	KPIT= 462.81	KYAW= 471.63		
MOM OF INERTIA	ROLL= 1888436.	PITCH= 12784919.	YAW= 13276903.		
PROD OF INERTIA	ROL-PIT= -10978.	PIT-YAW= 1732.	YAW-ROL= 35363.		

C.G. AS % L = 67.8 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

HYD APU LO	142.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU RO	142.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	352.	870.	0.	360.	1.	1.	1.	0	628.	1070.
OAMS LOSS H	160.	870.	0.	360.	1.	1.	1.	0	628.	1070.
COLD HE	38.	956.	0.	365.	1.	1.	1.	0	936.	972.
ENT ACS LO	390.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS RO	389.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ENT ACS H	221.	870.	0.	360.	1.	1.	1.	0	628.	1070.

ENTRY ACS

W= 1834.0	X=	1477.47	Y=	-0.05	Z=	306.78
RAD OF GYRATION	KROL=	81.65	KPIT=	515.90	KYAW=	518.33
MOM OF INERTIA	ROLL=	2639.	PITCH=	105356.	YAW=	106352.
PROD OF INERTIA	ROL-PIT=	-8.	PIT-YAW=	1.	YAW-ROL=	-9257.

ACCUM. TOTAL = ENTRY ACS

ACCUM. TOTAL = ENTRY WT

W= 278375.9	X=	1481.64	Y=	-0.14	Z=	292.39
RAD OF GYRATION	KROL=	177.41	KPIT=	463.18	KYAW=	471.96
MOM OF INERTIA	ROLL=	1891205.	PITCH=	12890470.	YAW=	13383381.
PROD OF INERTIA	ROL-PIT=	-10986.	PIT-YAW=	1733.	YAW-ROL=	26084.

C.G. AS % L = 67.8 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

40K POLAR MISSION UNITS = INCH

DEORBIT OL	2042.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
DEORBIT OR	2042.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
DEORBIT H	817.	870.	0.	360.	1.	1.	1.	0	628.	1070.

RETRO PROP

W= 4901.0	X=	1740.80	Y=	0.00	Z=	283.34
RAD OF GYRATION	KROL=	88.19	KPIT=	390.99	KYAW=	397.86
MOM OF INERTIA	ROLL=	8227.	PITCH=	161713.	YAW=	167451.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	-14127.

ACCUM. TOTAL = RETRO PROP

ACCUM. TOTAL = PRE RETRO WT

W= 283276.9	X=	1486.13	Y=	-0.14	Z=	292.24
RAD OF GYRATION	KROL=	176.26	KPIT=	463.27	KYAW=	471.98
MOM OF INERTIA	ROLL=	1899517.	PITCH=	13122165.	YAW=	13620719.
PROD OF INERTIA	ROL-PIT=	-10949.	PIT-YAW=	1732.	YAW-ROL=	9520.

C.G. AS % L = 68.1 %

ASCENT LGOX	31.	742.	-50.	228.	1.	1.	1.	0	387.	926.
ASCENT RGOX	30.	742.	50.	228.	1.	1.	1.	0	387.	926.
ASCENT LGH	17.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
ASCENT RGH	18.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
MANEU OL	1479.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
MANEU OR	1478.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
MANEU H	736.	870.	0.	360.	1.	1.	1.	0	628.	1070.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

ECS N	67.	850.	0.	445.	1.	1.	1.	0	840.	860.
ECS OL	11.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ECS OR	12.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ECS H	234.	870.	0.	360.	1.	1.	1.	0	628.	1070.
EPS OL	284.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
EPS OR	285.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
EPS H	71.	870.	0.	360.	1.	1.	1.	0	628.	1070.
ACS OL	259.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
ACS OR	258.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
ACS H	146.	870.	0.	360.	1.	1.	1.	0	500.	1080.
COLD HE	25.	956.	0.	365.	1.	1.	1.	0	936.	972.
OAMS LOSS LO	13.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
OAMS LOSS RO	13.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
OAMS LOSS H	1268.	870.	0.	360.	1.	1.	1.	0	628.	1070.

ON ORB LOSS

W=	6735.0	X=	1506.27	Y=	0.00	Z=	303.09
RAD OF GYRATION	KROL=	84.13	KPIT=	512.01	KYAW=	514.57	
MOM OF INERTIA	ROLL=	10290.	PITCH=	381083.	YAW=	384907.	
PROD OF INERTIA	ROL-PIT=	6.	PIT-YAW=	-0.	YAW-ROL=	-32531.	

ACCUM. TOTAL = ON ORB LOSS

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

40K POLAR MISSION UNITS = INCH

CARGO	40000.	1420.	0.	400.	64.	218.	218.	0	1120.	1840.

LANDED CARGO

W=	-40000.0	X=	1420.00	Y=	0.00	Z=	400.00
RAD OF GYRATION		KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA		ROLL=	-35363.	PITCH=	-410304.	YAW=	-410304.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ACCUM. TOTAL = LANDED CARGO

CARGO	40000.	1420.	0.	400.	64.	218.	218.	0	1120.	1840.

ASCENT CARGO

W=	40000.0	X=	1420.00	Y=	0.00	Z=	400.00
RAD OF GYRATION		KROL=	64.00	KPIT=	218.00	KYAW=	218.00
MOM OF INERTIA		ROLL=	35363.	PITCH=	410304.	YAW=	410304.
PROD OF INERTIA		ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ACCUM. TOTAL = ASCENT CARGO

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA (INCHES)		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES

40K POLAR MISSION UNITS = INCH

ACCUM. TOTAL = ON ORBIT WT

W= 290011.9	X=	1486.59	Y=	-0.13	Z=	292.49				
RAD OF GYRATION	KROL=	174.68	KPIT=	464.47	KYAW=	473.03				
MOM OF INERTIA	ROLL=	1909974.	PITCH=	13504138.	YAW=	14006346.				
PROD OF INERTIA	ROL-PIT=	-10939.	PIT-YAW=	1734.	YAW-ROL=	-22717.				

C.G. AS % L = 68.1 %

MANEU OL	736.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
MANEU OR	735.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
MANEU H	294.	870.	0.	360.	1.	1.	1.	0	628.	1070.

MANEUV PROP

W= 1765.0	X=	1740.93	Y=	-0.05	Z=	283.32				
RAD OF GYRATION	KROL=	88.19	KPIT=	390.87	KYAW=	397.75				
MOM OF INERTIA	ROLL=	2963.	PITCH=	58201.	YAW=	60269.				
PROD OF INERTIA	ROL-PIT=	-3.	PIT-YAW=	0.	YAW-ROL=	-5084.				

ACCUM. TOTAL = MANEUV PROP

RESER OL	2642.	742.	-50.	228.	1.	1.	1.	0	387.	926.
RESER OR	2642.	742.	50.	228.	1.	1.	1.	0	387.	926.
RESER HL	440.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
RESER HR	441.	1331.	60.	228.	1.	1.	1.	0	926.	1739.
DUMPED OL	1894.	742.	-30.	228.	1.	1.	1.	0	387.	826.
DUMPED OR	1894.	742.	30.	228.	1.	1.	1.	0	387.	926.
DUMPED HL	172.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

DUMPED HR	173.	1331.	60.	228.	1.	1.	1.	0	926.	1739.

DUMPED PROP

W= 10298.0	X=	812.12	Y=	0.01	Z=		228.00
RAD OF GYRATION	KROLL=	45.20	KPITCH=	190.75	KYAW=		196.03
MOM OF INERTIA	ROLL=	4542.	PITCH=	80875.	YAW=		85415.
PROD OF INERTIA	ROL-PIT=	13.	PIT-YAW=	0.	YAW-ROL=		0.

ACCUM. TOTAL = DUMPED PROP

ACCUM. TOTAL = INJECTION WT

W= 302074.9	X=	1465.08	Y=	-0.13	Z=		290.24
RAD OF GYRATION	KROLL=	171.89	KPITCH=	474.15	KYAW=		482.16
MOM OF INERTIA	ROLL=	1926417.	PITCH=	14657997.	YAW=	15157860.	
PROD OF INERTIA	ROL-PIT=	-11130.	PIT-YAW=	1714.	YAW-ROL=		64842.

C.G. AS % L = 67.0 %

AUX LO	4729.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
AUX RO	4729.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
AUX H	2788.	870.	0.	360.	1.	1.	1.	0	628.	1070.
OAMS LOSS H	35.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
SHUTDN LO	88.	742.	-50.	228.	1.	1.	1.	0	387.	926.
SHUTDN RO	88.	742.	50.	228.	1.	1.	1.	0	387.	926.
SHUTDN LH	40.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
SHUTDN RH	40.	1331.	60.	228.	1.	1.	1.	0	926.	1739.

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

MAIN LB	56417.	890.	-60.	228.	1.	1.	1.	0	845.	926.
MAIN RB	56417.	890.	60.	228.	1.	1.	1.	0	845.	926.
MAIN LH	9402.	1637.	-60.	228.	1.	1.	1.	0	1535.	1739.
MAIN RH	9403.	1637.	60.	228.	1.	1.	1.	0	1535.	1739.

ASCENT PROP

W= 144181.0	X=	1054.37	Y=	0.00	Z=	233.21
RAD OF GYRATION	KROL=	65.05	KPIT=	339.52	KYAW=	344.48
MOM OF INERTIA	ROLL=	131702.	PITCH=	3587354.	YAW=	3692939.
PROD OF INERTIA	ROL-PIT=	8.	PIT-YAW=	-0.	YAW-ROL=	55469.

ACCUM. TOTAL - ASCENT PROP

ACCUM. TOTAL - 75% BURN

W= 446255.9	X=	1332.39	Y=	-0.09	Z=	271.81
RAD OF GYRATION	KROL=	148.59	KPIT=	476.47	KYAW=	482.29
MOM OF INERTIA	ROLL=	2126643.	PITCH=	21867264.	YAW=	22404208.
PROD OF INERTIA	ROL-PIT=	-12234.	PIT-YAW=	1560.	YAW-ROL=	613723.

C.G. AS % L = 60.1 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR-MISSION UNITS • INCH

AUX L8	1406.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
AUX R8	1406.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
AUX H	562.	870.	0.	360.	1.	1.	1.	0	628.	1070.
HYD APU L8	29.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU R8	30.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
HYD APU H	73.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN L8	56417.	797.	-55.	228.	1.	1.	1.	0	742.	845.
MAIN R8	56417.	797.	55.	228.	1.	1.	1.	0	742.	845.
MAIN LH	9403.	1433.	-60.	228.	1.	1.	1.	0	1331.	1535.
MAIN RH	9403.	1433.	60.	228.	1.	1.	1.	0	1331.	1535.

ASCENT PR8P

W= 135151.0	X=	909.63	Y=	0.00	Z=	229.47
RAD 8F GYRATI8N	KR8L=	57.53	KPIT=	265.20	KYAW=	270.95
M8M 8F INERTIA	R8LL=	96556.	PITCH=	2051619.	YAW=	2141505.
PR8D 9F INERTIA	R8L-PIT=	19.	PIT-YAW=	1.	YAW-R8L=	24231.

ACCUM. T8TAL = ASCENT PR8P

ACCUM. T8TAL = 50% BURN

W= 581406.9	X=	1234.11	Y=	-0.07	Z=	261.97
RAD 8F GYRATI8N	KR8L=	134.30	KPIT=	472.03	KYAW=	476.95
M8M 8F INERTIA	R8LL=	2263331.	PITCH=	27960768.	YAW=	28547472.
PR8D 8F INERTIA	R8L-PIT=	-13039.	PIT-YAW=	1478.	YAW-R8L=	1038733.

C.G. AS % L = 55.0 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

AUX LO	1406.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
AUX RO	1406.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
AUX H	562.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN LO	56417.	685.	-45.	228.	1.	1.	1.	0	613.	742.
MAIN RO	56417.	685.	45.	228.	1.	1.	1.	0	613.	742.
MAIN LH	9403.	1230.	-60.	228.	1.	1.	1.	0	1128.	1331.
MAIN RH	9403.	1230.	60.	228.	1.	1.	1.	0	1128.	1331.

ASCENT PROP

W= 135019.0	X=	787.34	Y=	0.00	Z=		229.38
RAD OF GYRATION	KROL=	49.64	KPIT=	250.40	KYAW=		254.87
MOM OF INERTIA	ROLL=	71814.	PITCH=	1827312.	YAW=	1893031.	
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	28732.	

ACCUM. TOTAL = ASCENT PROP

ACCUM. TOTAL = 25% BURN

W= 716425.9	X=	1149.91	Y=	-0.05	Z=		255.83
RAD OF GYRATION	KROL=	123.55	KPIT=	472.58	KYAW=		476.85
MOM OF INERTIA	ROLL=	2360248.	PITCH=	34534176.	YAW=	35161472.	
PROD OF INERTIA	ROL-PIT=	-13739.	PIT-YAW=	1427.	YAW-ROL=	1411758.	

C.G. AS % L = 50.6 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS	ES
									(INCHES)	

40K POLAR MISSION UNITS = INCH

AUX LB	1406.	1915.	-89.	268.	1.	1.	1.	0	1870.	1965.
AUX RB	1406.	1915.	89.	268.	1.	1.	1.	0	1870.	1965.
AUX H	562.	870.	0.	360.	1.	1.	1.	0	628.	1070.
STAGE PNEU	5.	1825.	0.	250.	120.	40.	120.	0	1810.	1840.
MAIN LB	56417.	520.	-53.	228.	1.	1.	1.	0	387.	613.
MAIN RB	56417.	520.	53.	228.	1.	1.	1.	0	387.	613.
MAIN LH	9403.	1026.	-60.	228.	1.	1.	1.	0	926.	1128.
MAIN RH	9403.	1026.	60.	228.	1.	1.	1.	0	926.	1128.

ASCENT PROP

W= 135019.0	X=	621.04	Y=	0.00	Z=	229.38
RAD OF GYRATION	KROL=	55.85	KPIT=	258.19	KYAW=	263.76
MOM OF INERTIA	ROLL=	90908.	PITCH=	1942669.	YAW=	2027481.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	35434.

ACCUM. TOTAL - ASCENT PROP

ACCUM. TOTAL - IGNITION

W= 851444.9	X=	1066.05	Y=	-0.05	Z=	251.63
RAD OF GYRATION	KROL=	115.89	KPIT=	485.70	KYAW=	489.57
MOM OF INERTIA	ROLL=	2468305.	PITCH=	43352832.	YAW=	44047808.
PROD OF INERTIA	ROL-PIT=	-14436.	PIT-YAW=	1392.	YAW-ROL=	1790145.

C.G. AS % L = 46.2 %

ITEM	WEIGHT (LB)	CENTER OF GRAVITY (INCHES)			RADII OF GYRATION (INCHES)			DIST. DATA		
		X	Y	Z	ROLL	PITCH	YAW	DI	BS (INCHES)	ES

40K POLAR MISSION UNITS = INCH

MAIN LO	782.	742.	-50.	228.	1.	1.	1.	0	387.	926.
MAIN RO	782.	742.	50.	228.	1.	1.	1.	0	387.	926.
MAIN LH	199.	1331.	-60.	228.	1.	1.	1.	0	926.	1739.
MAIN RH	199.	1331.	60.	228.	1.	1.	1.	0	926.	1739.

STARTUP

W= 1962.0	X=	861.48	Y=	0.00	Z=	228.00
RAD OF GYRATION	KROL=	52.19	KPIT=	236.85	KYAW=	242.53
MOM OF INERTIA	ROLL=	1154.	PITCH=	23757.	YAW=	24910.
PROD OF INERTIA	ROL-PIT=	0.	PIT-YAW=	0.	YAW-ROL=	0.

ACCUM. TOTAL - STARTUP

ACCUM. TOTAL - LAUNCH WT

W= 853406.9	X=	1065.58	Y=	-0.05	Z=	251.58
RAD OF GYRATION	KROL=	115.79	KPIT=	485.37	KYAW=	489.25
MOM OF INERTIA	ROLL=	2469695.	PITCH=	43394464.	YAW=	44090368.
PROD OF INERTIA	ROL-PIT=	-14440.	PIT-YAW=	1391.	YAW-ROL=	1792196.

C.G. AS % L = 46.2 %